



**CONFÉRENCE DES NATIONS UNIES
SUR L'APPLICATION DE LA SCIENCE ET DE LA TECHNIQUE
DANS L'INTÉRÊT DES RÉGIONS PEU DÉVELOPPÉES**

E/CONF.39/A/300

1 Nov.1962

ORIGINAL : FRANCAIS

Point de l'ordre du jour : A.5

Roumanie

**LA POLITIQUE D'EXPLOITATION
DES RESSOURCES MINÉRALES**

Par M. GURAN,
Ingénieur,
Candidat ès Sciences Techniques,
Ingénieur-Conseil auprès du Comité
pour la Nouvelle Technique

Les mémoires rédigés à l'intention de la Conférence des Nations Unies sur l'application de la science et de la technique dans l'intérêt des régions peu développées sont des documents de travail. Ils sont publiés tels qu'ils ont été présentés et les assertions et opinions qu'ils contiennent sont celles de leurs auteurs.

NOTES

1. Les mémoires choisis pour être présentés en séance générale pourront être obtenus à la Conférence dans les langues officielles suivantes des Nations Unies: anglais, espagnol, français et russe.
2. Les mémoires choisis pour être présentés en séance spéciale pourront être obtenus à la Conférence dans l'une seulement de ces langues officielles.
3. Les résumés qui ont été rédigés pour tous les mémoires par les auteurs de ceux-ci pourront être obtenus à la Conférence dans les langues officielles suivantes des Nations Unies: anglais, espagnol, français et russe.
4. Préalablement à la Conférence, les mémoires et les résumés ne feront pas l'objet d'une distribution générale mais d'un tirage restreint destiné aux délégations des gouvernements et autres participants officiels. La publication et la distribution générale des actes de la Conférence s'effectueront conformément aux règles et pratiques agréées par le Comité des publications des Nations Unies.

LA POLITIQUE D'EXPLOITATION DES RESSOURCES MINÉRALES

Ing. M. Guran, Candidat ès Sciences Techniques, Ingénieur-Conseil
auprès du Comité pour la Nouvelle Technique

Importance des ressources minérales pour l'ensemble du développement économique

1. Afin de créer une base technique et matérielle moderne nécessaire à un développement économique ferme, il faut accorder une importance particulière à une juste politique d'exploitation des ressources minérales, qui permette d'assurer un développement préférentiel de l'industrie lourde - industrie sidérurgique, métallurgie des métaux non ferreux, industrie chimique, industrie des matériaux réfractaires, construction des machines, etc.

2. Le développement rapide de l'industrie lourde - avec son noyau, la construction des machines - rend possible la reconstruction technique de toute l'économie, ainsi que la création d'une nouvelle base technique sur laquelle puisse s'appuyer l'augmentation du potentiel économique des pays en cours de développement et, par conséquent, l'accroissement du niveau de vie des peuples respectifs. Pour créer et développer rationnellement une industrie moderne, il faut aujourd'hui solutionner un grand nombre de problèmes de nature scientifique.

3. C'est la raison pour laquelle nous croyons qu'il faut accorder une attention toute spéciale au développement de l'activité scientifique concernant la prospection, l'exploration, les recherches et l'élaboration des projets. D'autre part, afin que le développement de ces activités soit possible, il est nécessaire de former un nombre convenable de cadres qualifiés de techniciens, géologues, ingénieurs, chercheurs et élaborateurs de projets.

4. Les problèmes mentionnés étant particulièrement actuels pour la quasi - totalité des pays en cours de développement, nous tâcherons de présenter dans le présent rapport, certains aspects du mode dont ils ont été résolus dans la République Populaire Roumaine, en commençant par faire ressortir que, dans notre pays, la politique d'exploitation des ressources minérales représente une partie intégrante de la politique d'industrialisation socialiste, qui est réalisée, organiquement, dans le cadre du développement planifié de l'ensemble de l'économie nationale.

5. a) La République Populaire Roumaine possède diverses substances minérales utiles - minerais de fer, de manganèse, polymétalliques (Pb, Zn, Cu), auro-argentifères, pyrites, bauxite, barytine, argiles réfractaires, kaoline, bentonite, feldspath, talc, sel gemme, etc. - formant l'objet d'un grand nombre d'exploitations minières.

b) En outre, dans plusieurs gisements récemment découverts, en

y déploie une activité intense de prospections et d'exploration, afin d'organiser de nouvelles entreprises minières.

6. a) Jusqu'à la fin de la seconde guerre mondiale, les richesses du sous-sol roumain ont été insuffisamment étudiées et irrationnellement mises en valeur; en général, elles constituaient une source de profits immédiats, surtout pour le capital étranger.

b) L'industrie extractive des minerais ferreux, non ferreux et non métallifères ne dépassait qu'à peine 1% du total de la production globale industrielle de l'année 1938, ce qui explique le niveau extrêmement bas à cette époque de la production nationale d'acier, de laminés et de métaux non-ferreux. C'est pourquoi la Roumanie se trouvait obligée d'importer environ 50% des métaux nécessaires et 95% environ des machines et de l'outillage.

7. a) Pendant la période de l'industrialisation socialiste, par suite de l'application d'un programme complexe concernant la mise en valeur des ressources minérales du pays, la production des minerais de fer, ainsi que la production de la fonte, de l'acier et des laminés a subi un accroissement continu et rapide, ainsi que le montre le tableau ci-dessous :

	1938	1950	1961
b) Minerai de fer en milliers de to.	139	392	1 737
c) Fontes " " "	133	320	1 099
d) Aciers " " "	284	555	2.127
e) Laminés " " "	319	459	1 920

f) D'importants accroissements ont été obtenus également dans la production des autres minerais : manganèse, non ferreux et non métallifères. Ainsi, depuis 1950 la production des minerais polymétalliques s'est accrue de 3 fois et celle des produits cuprifères, de 10,6 fois.

8. a) Une importance toute particulière est attribuée à la planification rationnelle de l'activité de recherche géologique pour la mettre d'accord avec les nécessités du développement de l'industrie.

b) Les plans annuels de recherches géologico-minières qui sont élaborés en utilisant des études technico-économiques, déterminent - par bassins miniers, gisements et sortes de minéraux - le volume des travaux nécessaires, la quantité des réserves à être mises en évidence et le rendement des travaux géologiques.

c) Les études technico-économiques ayant été favorablement avisées, on procède à l'élaboration des projets de travaux, qui permettent de développer les méthodes de prospection et d'exploration, précisant les emplacements des travaux miniers et de forage et les phases de leur exécution.

d) Les recherches, dont l'objet est d'établir les méthodes appropriées pour l'extraction des minerais, ainsi que les technologies pour leur traitement, sont précisées par les plans annuels de recherches technico-scientifiques.

Réalisations récentes concernant les prospections,
l'exploitation et la préparation des minerais

9. a) Les travaux de prospection géologique, géophysique (magnétométrie et électrométrie) et géochimique ont permis de détecter de nouveaux

gîtes de minéraux et d'augmenter ainsi les réserves de minerais ferreux, non ferreux et non métallifères.

9.b) Méthodes de prospection

9.b)1) Le bilan des réalisations, obtenues au moyen des recherches géologiques exécutées dernièrement, a confirmé que, en effectuant systématiquement des travaux et en appliquant des méthodes combinées de recherches, on peut obtenir de très bons résultats en ce qui concerne aussi bien la quantité des réserves mises en évidence, que le rendement économique des travaux.

ii) Les méthodes utilisées pour la prospection des minerais métallifères et non métallifères sont : les prospections géologiques, les prospections géochimiques et les prospections géophysiques.

iii) La prospection géologique s'exécute soit par l'observation et l'étude des ouvertures naturelles du terrain, soit par des forages et des travaux miniers. Les travaux de prospection sont fondés sur les projets de recherches.

iv) Comme méthode de travail sur le terrain, nous devons mentionner que, en fonction de la morphologie de la région, de son rapport de découverte et de la précision voulue, on pratique l'étude des ouvertures naturelles, soit sur un itinéraire qui suit les vallées et les crêtes, soit sur un itinéraire orienté selon le réseau rectangulaire.

v) En utilisant les informations récoltées sur le terrain et les analyses physico-chimiques, minéralogiques et paléontologiques effectuées en laboratoire, on construit la carte géologique à l'échelle respective, avec les sections géologiques nécessaires et les blocs-diagrammes en divers systèmes de projection. On insiste particulièrement sur les points ou les zones où a été déterminée la présence des substances minérales utiles ou bien des traces d'anciennes exploitations minières (éboulements, dépôts de stérile, etc.), tout en indiquant tous les détails les concernant.

vi) Depuis quelque temps, on utilise, dans les prospections géologiques, des photographies aériennes à l'échelle de 1: 20 000 - 1:10 000 qui contiennent, généralement, des détails du terrain que l'on ne trouve pas dans les cartes topographiques, même les plus minutieuses.

vii) Les prospections géochimiques sont, en général, exécutées dans les régions recouvertes, ou ayant favorisé la migration des éléments métalliques. Les résultats des analyses chimiques des échantillons récoltés permettent de construire la carte géochimique indiquant les contours des zones d'anomalie et de dresser les profils géochimiques.

viii) Pour les prospections géophysiques, on applique dans le domaine des minerais métallifères, les méthodes de prospection électrométrique et magnétométrique.

9.c) Perspectives dans le domaine de la prospection des ressources minérales.

9.c)1) L'expérience accumulée dans la pratique des recherches géologiques, a créé des conditions favorisant l'augmentation des capacités de prospection et d'exploration géologique.

ii) En conséquence, les travaux de prospection des minerais en cours d'exécution durant la période de 1960 - 1965 accuseront un accroissement de plus de 50 % par rapport au volume des prospections réalisés dans les 6 années précédentes. Afin d'obtenir une augmentation du rendement économique des travaux de recherche géologique et des bases solides pour les travaux d'exploration, on donnera plus d'ampleur et l'on intensifiera les

travaux de prospection géophysique - en utilisant surtout la magnétométrie et l'électrométrie - de même que ceux de prospection géochimique et radiométrique.

9.d) Méthodes d'exploitation

9.d.1) Les méthodes appliquées à l'exploitation des gisements de minerais dépendent des éléments géométriques du gisement et de sa nature, ainsi que des caractéristiques physico-mécaniques des roches encaissantes.

ii) Selon les conditions du gisement, les méthodes d'exploitation peuvent être classées en: méthodes d'exploitation par simple remblayage de l'excavation (défilage par chambre remblayée); méthodes d'exploitation par soutènement naturel de l'excavation (défilage par chambre vide proprement dite); méthodes d'exploitation par soutènement et remblayage; méthodes d'exploitation par chambre foudroyée; méthodes d'exploitation par chambre-magasin.

iii) Ainsi, dans les gisements filoniens polymétalliques et aurifères, on applique des méthodes d'exploitation par tranches, à remblayage de l'excavation. Pour les filons épais de 0,5 - 20 m et à pendage de 70° - 85°, c'est la méthode d'exploitation par chambre magasin, l'abattage étant fait par gradins renversés, méthode qui s'avère comme la plus efficace. L'exploitation des gisements entrecroisés et des amas de minerais est effectuée, en fonction des dimensions des corps minéralisés et des caractéristiques des roches encaissantes, soit par tranches horizontales montantes, directionnelles ou transversales, à soutènement et remblai complet, soit par tranches horizontales montantes ou descendantes et par chambres remblayées.

iv) Dans le cas des couches de minerais de fer, de 1-3 m d'épaisseur, à pendage de 10° - 30° se prolongeant suffisamment dans des formations de roches tendres ou semi-dures, on appliquera la méthode d'exploitation chassante par front long et par remblai partiel et foudroyage. Les lentilles et les amas de minerais sont exploités par la méthode des chambres à remblai complet.

v) Récemment, dans le cas de ce type de gisement, on a obtenu de très bons résultats en appliquant les méthodes d'exploitation par chambres-magasins et par sous-étages, dont l'application a déjà été adoptée par deux grandes exploitations de mines de fer. Dans les gisements non métallifères disposées en couches et localisées, en général, dans des roches sédimentaires, tendres ou semi-douces, on applique la méthode d'exploitation par chambres et piliers.

vi) Quant à l'exploitation à ciel ouvert, elle n'est appliquée qu'à un seul minerai de fer situé près de la surface.

9.e) Caractérisation technico-économique de quelques méthodes d'exploitation

9.e.1) En ce qui concerne les caractéristiques des principales méthodes d'exploitation, il faut mentionner: la méthode d'abattage par tranches montantes remblayées - directionnelles ou transversales - appliquée aux gisements filoniens encaissés dans des roches semi-dures ou dures mais fissurées.

ii) Les blocs ont des dimensions de 40-60 m en direction et de 30-35 m en pendage. Le chargement et le transport dans les tailles sont exécutés soit à la main, soit au scraper (fig.1).

iii) La méthode d'exploitation par chambres-magasins offre plusieurs avantages techniques et économiques par rapport aux autres méthodes utilisées dans les gisements filoniens. Les panneaux d'exploitation ont des dimensions de 60 m en direction et de 45-60 m en pendage (fig.2).

iv) De cette manière, le transport dans les tailles et le chargement du minerai provenant des chutes sont faits par l'effet de la pesanteur. L'application expérimentale de la méthode d'abattage par chambres-magasins à l'exploitation des minerais de fer, a permis de réaliser des rendements trois fois plus grands que ceux obtenus par la méthode par chambres-remblayées, mais par contre le salissage a augmenté dans ce cas de 10 - 15 % (fig.3). En outre, on a appliqué aussi, à l'extraction du minerai de fer, la méthode de défilage par sous-étages (fig.4).

v) L'exploitation par tranches horizontales ou par chambres charpentées et remblayées, ou encore simplement remblayées, est appliquée aux gisements en formes d'amas, de lentilles et de corps irréguliers de grande épaisseur, 20-40 m. Les dimensions des panneaux sont d'environ 50 x 25 - 30 m. (fig.5).

9.f) Les tendances dans la mécanisation des opérations exigeant un travail difficile.

9.f)i) C'est dans cette direction que l'on a procédé, dans toutes les mines, à des études analytiques d'une grande diversité, y compris l'aspect très important de la mécanisation des opérations exigeant un travail difficile ou un grand volume de main-d'œuvre. Les progrès réalisés dans ce domaine présentent un aspect dynamique nettement ascendant et l'on continue d'intensifier cette activité.

ii) Par exemple, dans les avancements, la perforation est exécutée mécaniquement par des perforateurs de type lourd (27-30 kg.) et demi-lourd (17-23 kg.) appuyés sur des supports pneumatiques. On est en train d'expérimenter plusieurs chargeuses de fabrication indigène et étrangère.

iii) En ce qui concerne les opérations d'abattage, le forage des trous de mise est complètement mécanisé.

iv) L'exploitation à ciel ouvert des mines de fer est elle-aussi mécanisée. On y emploie des sondeuses sur chenilles, le tir à fortes charges d'explosif, le chargement par excavateur et le transport par camions basculants de 10 tonnes.

9.g) Méthode de préparation des substances minérales utiles.

9.g)i) L'augmentation de la production de matières premières minérales a soulevé, en outre, des problèmes très importants dans le domaine de la technique de préparation des substances utiles. Ces problèmes se rattachent, d'une part, à l'amélioration des processus technologiques dans les usines de préparation existantes et, d'autre part, à l'établissement des technologies optimales pour la mise en valeur des minerais dans les nouveaux gisements. En outre, on a commencé et l'on continue les recherches nécessaires pour la mise en valeur complexe et intégrale des minéraux utiles contenus dans la matière première minière.

ii) Dans le stade actuel, on applique, en fonction des caractéristiques physico-chimiques et minéralogiques des minerais, les méthodes d'enrichissement suivantes : la flottation (collective et différentielle) pour les minerais non ferreux et la barytine; l'amalgamation, la flottation et la cyanuration pour les minerais auro-argentifères; la concentration magnétique en champ de faible intensité, avec ou sans grillage magnétisant, ainsi que la concentration magnétique de grande intensité, pour les minerais de fer; des méthodes gravitationnelles pour les minerais de manganèse; le lavage et la séparation par hydroclasseurs pour les sables kaoliniques.

iii) En outre, on a réussi à préparer certains minerais complexes fins et difficiles à traiter. Dans le schéma de la figure 6, par

exemple, est représenté le flux technologique de la flottation des minerais complexes de plomb et de zinc dans l'installation Deva II. L'élément nouveau de cette technologie est l'introduction du classement par hydrocyclone dans le second échelon de broyage, L'installation, dont la capacité est de 500 t/24 h permet de tirer d'un minerai avec une teneur à l'origine de 1,60% Pb et 2,90% Zn, des concentrés de plomb à 52-55% Pb, avec une extraction métallique de 72-75% et des concentrés de zinc à 43-46% Zn avec une extraction métallique de 73-75%. Le minerai est oxydé et finement concrétionné. Le broyage fournit une finesse de 90%, à travers le tamis à 200 mailles/inch.

iv) Les nécessités toujours plus grandes en minerais de fer ont imposé l'augmentation de la capacité des usines destinées à l'enrichissement de ces minerais.

v) Le schéma présenté dans la figure 7, permet d'obtenir des concentrés de sidérose grillée à une teneur de 52-55% Fe avec une extraction en métal de 90-92%. Les concentrés à une granulation de 0 - 0,3 mm sont pelletisés et agglomérés sur bande.

vi) Dans la figure 8, est représenté le schéma technologique de la préparation de certains minerais oolithiques. Par lavage et concentration d'un minerai oolithique ayant une teneur d'environ 30% Fe dans un champ magnétique de grande intensité, on obtient des concentrés de 50-52% Fe avec une extraction en métal de 89%. Les concentrés, dont la granulation est de 0 - 1 mm sont pelletisés et agglomérés.

Politique d'exploitation rationnelle des ressources minérales

10. a) Dans le développement de l'industrie minière et de la réalisation des prévisions du plan d'extraction des minerais, il est très important d'assurer une exploitation rationnelle des ressources minières. Dans ce domaine, l'attention a été dirigée vers les objectifs suivants: l'établissement de l'ordre d'exploitation des gisements et l'élaboration des programmes annuels d'exploitation; la réalisation rythmique du programme de recherches géologiques minutieuses et l'établissement des projets pour les travaux préparatoires de mise en exploitation des nouveaux gisements; le choix de la méthode la mieux appropriée d'exploitation et de préparation.

10.b) Mentionnons que tous ces problèmes sont examinés et résolus par les projets de systématisation des mines actuelles ou devant être mises en exploitation dans un avenir plus ou moins proche.

11. Les recherches géologiques, minières et de préparation, l'inventaire en vue d'étendre la base propre de matières premières, et le développement rationnel de l'extraction et de la préparation à un niveau industriel aussi élevé que possible des ressources minérales sont les trois phases fondamentales de toute politique juste dans ce domaine. Par leur interdépendance, elles impliquent en outre, la nécessité de prendre des mesures qui tiennent compte en permanence du caractère à la fois multiple et d'ensemble de ce problème. Nous sommes d'avis que l'adoption de ces mesures se trouve facilitée, dans les pays en cours de développement, dans l'hypothèse de l'extension du rôle de l'Etat dans l'économie et de certaines mesures de planification capables d'intégrer, d'une part, le développement des diverses entreprises dans le développement de l'ensemble de l'industrie et, d'autre part, le développement de cette industrie dans l'ensemble de l'économie nationale. En outre, la nécessité d'organiser la production sur la base des plus nouvelles conquêtes de la science et de la technique - condition essentielle pour assurer la rentabilité de toute l'activité d'exploitation des ressources minérales - implique l'extension des formes de collaboration internationale, fondée sur le principe de l'égalité entre les pays, ainsi que l'orientation, vers l'accélération de l'augmentation de la puissance économique des pays en cours de développement.

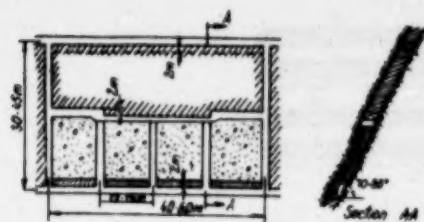


Fig. 1 - Schéma de la méthode d'exploitation par tranches horizontales, montantes en direction, à remblai

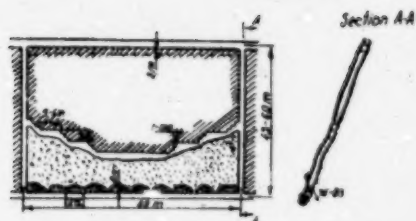


Fig. 2 - Schéma de la méthode d'exploitation par gradins renversés, par chambre-magasin

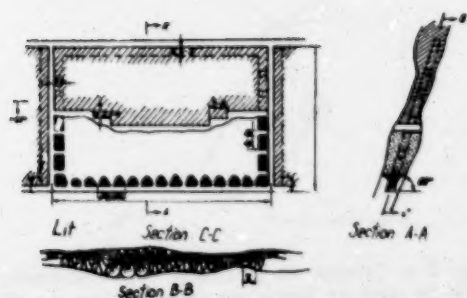


Fig. 3 - Schéma de la méthode d'exploitation par chambre-magasin appliquée aux gisements de fer

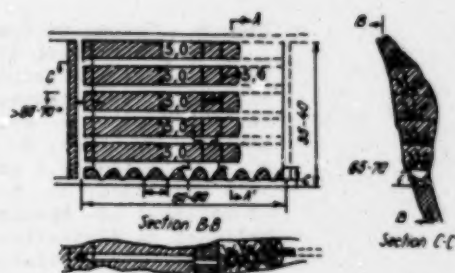


Fig. 4 - Schéma de la méthode d'exploitation par sous-étages appliqués aux gisements de minerais de fer

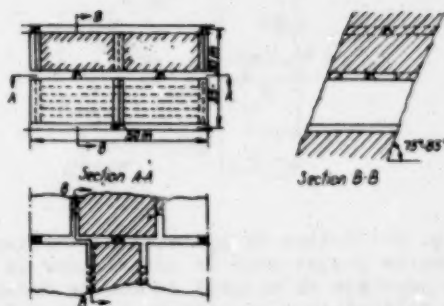


Fig. 5 - Schéma de la méthode d'exploitation par tranches horizontales, montantes, par chambre boisée et remblayée

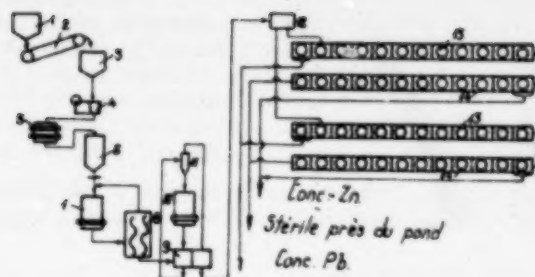


Fig. 6 - Schéma de traitement dans l'usine de préparation Deva II - Minerais complexes:
1- silo 30 t; 2- transporteur à courroie; 3- silo 400 t; 4- concasseur à mâchoires; 5- concasseur Symons; 6- silo 1000 t; 7- broyeur à boulets, 2700/300; 8- classificateur à double vis; 9- réservoir à pulpe; 10- broyeur à boulets 2400/2500; 11- batterie d'hydrocyclones (2 unités); 12- égaliseur pour la pulpe; 13- cellules de flottation, plomb; 14- cellules de flottation, zinc

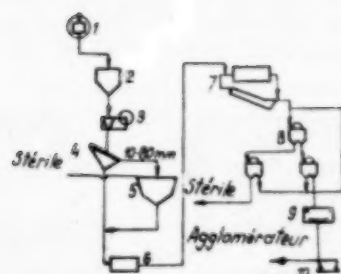


Fig. 7 - Schéma de principe du traitement dans le projet pour la préparation du minerai de fer de Teliuc:
1- téléphérique ou camion; 2- silo; 3- concasseur à mâchoires; 4- crible vibrateur; 5- séparateur pour liquide dense; 6- four à griller; 7- broyeur avec classificateur; 8- séparateur magnétique humide à tambour; 9- cône magnétique épaisseur; 10- filtre à surface inférieure de filtrage

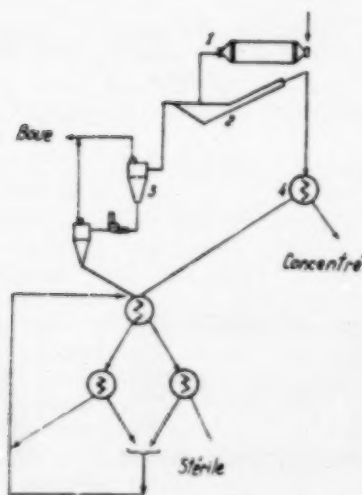


Fig. 8 - Schéma de principe du traitement dans le projet pour la préparation du minerai de fer de Capus:
1- broyeur à circuit ouvert; 2- classificateur à râteau; 3- microcyclone Ø 350 mm; 4- séparateur humide à champ magnétique

1389 F - Nov. 1962 - 1,000



UNITED NATIONS CONFERENCE
ON THE APPLICATION OF SCIENCE AND TECHNOLOGY
FOR THE BENEFIT OF THE LESS DEVELOPED AREAS

E/CONF.39/A/301

1 Nov.1962

ORIGINAL : ENGLISH

Agenda Item: A.5.1

Australia

GOVERNMENT ACTION IN DEVELOPING
THE MINERAL INDUSTRY IN AUSTRALIA

By J.M. RAYNER,
J.W. MORGAN,
and K.M. KENNEDY,
Geology and Geophysics,
Canberra, Australia

Papers have been contributed to the United Nations Conference on the Application of Science and Technology for the Benefit of the Less Developed Areas as working papers for that Conference. They are published as presented by the contributors, and the contents and the views expressed are those of the contributors. (See notes overleaf.)

NOTES

1. Papers selected for inclusion in General Sessions will be available at the Conference in the following official languages of the United Nations: English, French, Russian and Spanish.
2. Papers selected for inclusion in Specialized Sessions will be available at the Conference in only one of the above official languages.
3. Summaries of all papers, as submitted by contributors, will be available at the Conference in the following official languages of the United Nations: English, French, Russian and Spanish.
4. Papers and summaries will not be available for general distribution in advance of the Conference. They will be published in advance in limited quantities only for the use of delegations of participating governments and of other authorized participants. Post-Conference publication and general distribution of the Conference Proceedings will follow United Nations practices as laid down by the United Nations Publications Board.

GOVERNMENT ACTION IN DEVELOPING THE MINERAL INDUSTRY IN AUSTRALIA

J.M. Rayner,¹ J.W. Morgan¹ and K.M. Kennedy¹.

1. The development of Australian mineral resources has and continues to be largely in the hands of private enterprise. Nevertheless there are cases where the government, either Commonwealth or State, for strategic reasons or to meet special economic circumstances has entered into actual production. These excursions by government into specific fields of mineral production have been of major importance to a particular industry, but in the context of the whole Australian industry the direct contribution has been and remains relatively small.

2. It is the influence of government policies, both Commonwealth and State, on the activities of the private sector of the mineral industry that is of major importance. Industrial development and production programmes have been influenced to varying degrees by such policies in the past and it is certain that with the growing industrial awareness of the underdeveloped mineral potential, the future rate of development and its direction will more than ever reflect the attitude of governments.

REVIEW OF THE MINERAL INDUSTRY

3. The discovery of gold in 1851 was the first mineral discovery of any significance in the development of Australia. At that time the recorded population was only 500,000 but in a period of ten years this had doubled, largely as a result of the gold discoveries. Mineral discoveries of major importance followed rapidly and included tin at Mt. Bischoff in 1871, silver-lead-zinc at Broken Hill in 1883, copper at Mt. Lyell in 1890, gold at Coolgardie and Kalgoorlie in 1892 and 1893. Important discoveries of iron ore were also made late in the 19th century; coal had been known from the earliest days of settlement and by the end of the 19th century the existence of many of the major coal deposits was known.

4. Following this period of intensive prospecting and development the most significant discovery to the end of World War II was the lead-zinc deposit (and subsequently copper) at Mt. Isa. These and other discoveries and their development had far reaching effects on the economy as a whole. They helped to advance pastoral and agricultural development in many areas, and provided raw material and financial resources for the establishment of a wide range of secondary industries (iron and steel, chemical, engineering etc.) so vital to expansion.

5. In the post-World-War II era there has been an upsurge of exploration and development which has led to some remarkable successes -

¹ Bureau of Mineral Resources, Geology and Geophysics, Canberra, Australia.

notably the discovery of major uranium deposits now producing, extensive bauxite deposits now being developed, and significant new iron ore deposits now in the course of evaluation.

6. The post-war increased production has been partly absorbed internally but there has also been an increase in the volume of exports. The present output of the industry is worth £A250 million annually. Exports in 1961 were a record £A93.2 million or about 9% of all exports, the lead-zinc industry being the major contributor. Imports of mineral products in 1961 were valued at £A99.3 million of which crude petroleum accounted for £A78.5 million or 79%. Recent developments within the industry suggest a continuous expansion in exports and also some reduction in the value of imports. Increase in aluminium production will eliminate the need for imports with some excess for export in the near future; the possibility of commercial production of oil following the recent discovery in Queensland is an encouraging development.

GOVERNMENT POLICIES

7. In recent years there has been a trend to formulate government policies to encourage development with a maximum advantage to the country, at the same time permitting this development to be undertaken by private enterprise.

8. The Commonwealth of Australia comprises six States and two Territories and with a few exceptions each State holds sovereign rights to all minerals within its boundaries and administers its own mining legislation. This legislation thus varies from State to State. Notwithstanding the States' sovereign rights over their own mineral resources the Commonwealth Government is able to exert a direct influence on the production and development of the mineral industry through its control of international trade, customs and excise, income tax, and public borrowings.

9. Another important aspect of Government participation to be considered is the direct technical assistance sponsored by both State and Commonwealth Governments.

TECHNICAL SERVICES AND RESEARCH PROVIDED BY GOVERNMENT AGENCIES

10. State Mines Departments: Each State Government has a Mines Department which includes a Geological Survey. These Departments individually administer the mining legislation and have complete control of mining tenements within the State.

11. The Geological Surveys carry out regional geological mapping (in some cases in conjunction with the Bureau of Mineral Resources) and in general devote much of their effort to detailed mapping of localities of mining interest. Geophysical surveys are also undertaken by some States.

12. Technical officers of the Mines Departments provide advice to the mining and allied industries where required, carry out field examinations of mining prospects, advise on exploration and development, select sites for water supply, and in general give a free technical service to the mining industry. Assays and determinations of rocks and minerals are carried out for prospectors by the Departments, usually without charge.

13. Financial and practical assistance is given in a number of ways which vary from State to State. Loans, grants and subsidies are provided under certain circumstances and boring-plant, mining equipment and treatment works are available for hire at a reasonable charge. Assistance is provided for transport, such as road making, railways and port facilities. Some States give financial assistance to prospectors in the form of direct payments.

14. Commonwealth Bureau of Mineral Resources, Geology and Geophysics. The Bureau of Mineral Resources is a Commonwealth body, formally constituted in 1946. Its functions are:-

(a) to explore for, investigate and encourage the development of mineral deposits;

(b) to survey and assess the mineral resources of the Commonwealth and its Territories and to initiate and investigate proposals for their development;

(c) to interpret the results of completed surveys and recommend ways of remedying or meeting mineral deficiencies that may become apparent, and to advise on all aspects of the mineral economy of Australia, including the best utilization of mineral resources in the national interest; and

(d) to carry out geological and geophysical surveys and investigations, and advise on all aspects of applied geology and geophysics.

15. The Bureau employs a staff of approximately 460, of which almost 400 are technically trained, some 220 being professional officers.

16. The funds available to the Bureau have increased steadily. For the financial year 1950/51 the expenditure was £A438,000 which increased to £A843,000 for 1957/58. The search for oil caused an accelerated increase in 1961/62 when expenditure was £A1,782,000. Estimated expenditure for the current financial year, 1962/63, is £A2,283,000. These amounts do not include subsidies paid to the petroleum exploration companies, though the Bureau administers the Subsidy Acts.

17. The activities of the Bureau are subject to change to meet the needs at any particular time. Much of the present effort is devoted to assisting in the search for oil.

18. The Bureau, in conjunction with the State Mines Department, is committed to carry out geological and geophysical regional mapping of the whole of Australia. The national grid on which most mapping is based is divided to give areas about 540 bounded by lines 1°30' longitude and 1° latitude apart. The scale is usually 1:250,000.

19. Up to now about 100 sheets (18.5% of the total area) have been geologically mapped at this scale. About 30 areas are mapped per year, 25 by the Bureau and the remainder by the State Surveys. Regional gravity coverage, at a station spacing of one station per 50 square miles has been undertaken by the Bureau, using helicopters for transport. About 12.5% of the continent has already been covered and at the present rate and spacing the survey will be completed by 1979. A similar regional aeromagnetic and scintillometric survey is under way and about 12% of the total has been completed. At present special effort is being given to mapping of the sedimentary basins to assist in the search for oil.

20. Commonwealth Scientific and Industrial Research Organization (C.S.I.R.O.): Geological mapping is not a specific undertaking of C.S.I.R.O. unless it is required to further research into another

field. For example, C.S.I.R.O. recently mapped the soil distribution of a large area in the centre of Australia as part of an investigation into pastoral development.

21. C.S.I.R.O. undertakes ore-dressing and mineragraphic investigations as required by the industry. For this purpose it maintains three laboratories, two within Departments of the University of Melbourne, and one at the School of Mines in the gold-mining centre of Kalgoorlie in Western Australia. These laboratories perform complementary services - the Mineragraphic Investigations Laboratory conducts microscopic examinations of the mineral associations and degree of dispersion in ores, whilst the Ore-Dressing Laboratories investigates methods of beneficiation. Much of this research is carried out on a co-operative research basis with the mineral industry.

22. Australian Mineral Development Laboratories (A.M.D.L.): These Laboratories are a joint undertaking by the Commonwealth Government, the Government of South Australia, and the Australian Mineral Industries Research Association. They were established on a national basis to offer a contract service for the investigation of problems relating to the development of mineral resources, mineral processing and utilization of mineral products. The Australian Mineral Industries Research Association is an association of companies engaged in the mineral industry, formed to foster and develop mineral research.

23. The wide variety of research facilities offered by the A.M.D.L. and complete integration of these services is of importance to many industries and to other groups which cannot afford a similar range of facilities or the specialized equipment necessary for the solution of their problems.

24. Leases and Royalties: The development of a mineral deposit in any State is subject to the mining laws of that particular State; in the Territories, to the ordinances of the Commonwealth. Any new development immediately benefits the State or Territory in which it takes place; this stems from increased employment opportunities, both direct and indirect. Furthermore royalties on production, where they are levied (the basis of royalty arrangements varies from State to State and also within individual States according to the nature of the commodity etc.), are an additional source of revenue. Greater returns may also accrue from State transport systems as well as other benefits arising from the new sphere of production.

GOVERNMENT AID AND INCENTIVES

25. Public Works: Accelerated capital works programmes financed partly by the Commonwealth and State Governments have in recent years, been recognized as of major assistance to development. Important projects now in hand include the rehabilitation of the Mt. Isa-Townsville railway (copper, lead, zinc); port facilities in New South Wales and Queensland (coal exports); and standardization of the Kalgoorlie-Kwinana railway (iron ore). A substantial proportion of this investment will be recovered later from mineral freights but the immediate availability of these government funds has accelerated development which, if dependent on private finance, undoubtedly would have been delayed. Other industries too will naturally benefit from such projects.

26. Taxation: The Commonwealth Government is the sole authority imposing income tax in Australia. The provisions of the Income Tax

and Social Services Contribution Act which aid the mining industry have been developed over the years in recognition of the special nature of the industry and the desirability of offering incentives for expansion.

27. As a guide to the present position, the following outline may prove useful.

(a) Exempt Income. Certain income derived by prospectors and proprietors of mining enterprises is specifically exempt from tax -

- (i) income derived from the disposal of the rights to mine for gold or for a metal or mineral prescribed by regulation,
- (ii) income derived from a property mined principally for gold,
- (iii) income from the mining and treatment of uranium ore,
- (iv) 20 per cent of net income derived from the production of prescribed metals or minerals; the list is the same as that which applies to (i) above - the most important minerals excluded are lead, zinc, silver, iron ore and coal.

(b) Deductions for Capital Expenditure. Capital expenditure is not an allowable deduction under the general provisions of the income tax law, but the position of the mining industry is distinguishable from that of other industries since its raw material reserves cannot be replaced. This is recognized in the income tax law, which permits special deductions for capital expended in a mining venture conducted for the purpose of earning assessable income. Briefly the allowances are available on the following basis.

(i) Exploration or Prospecting Expenditure. Deductions from the income of a year in which the exploration or prospecting expenditure is incurred are allowable up to the amount of net income derived from a mining business or associated activities during that year.

(ii) Expenditure on Necessary Plant and Development of the Mining Property. This expenditure is deductible over the estimated life of the mine or 25 years, whichever is the less. Alternatively, deductions are, at the option of the taxpayer, allowed for the year in which the capital is expended. A further alternative applies where a mine-owner appropriates assessable income of one income year for expenditure during the ensuing year on necessary plant or on development of the mining property. In these circumstances a deduction is available for the year in which the appropriated income was derived.

(iii) Expenditure on Housing and Welfare. Expenditure in this category is deductible over the estimated life of the mine or, if the taxpayer so elects, over a period of five years.

(c) Expenditure on Prospecting or Mining for Petroleum. The general effect of deductions allowable under this category is to free from income tax proceeds from petroleum income in Australia, the Australian Territory of Papua or the Trust Territory of New Guinea until such time as the capital expended in prospecting and mining for petroleum or in plant for its treatment has been firstly recouped. However there are circumstances where a company would have to forego these allowances, i.e. where the company elects on behalf of shareholders that they may deduct the full amount of share capital subscribed by them in determining their assessable income.

(d) Deductions Allowed to Shareholders. The owners of shares in a company or syndicate whose principal business is mining or prospecting is entitled to a deduction of calls paid by him on those shares in arriving at his assessable income. In all cases the amount of the allowable deduction is not less than one-third of the calls paid, but as an incentive to investment 100% may be deductible if the company so elects. If such an election is made then the company foregoes other deductions of a capital nature from its income when it comes into production.

(e) Exemption of Dividends. Dividends in the hands of share-holders are exempt from tax when paid wholly and exclusively out of net exempt income from mining operations or the sale of rights to mine, if the exception of the income is granted under the respective provisions of the Act.

28. Subsidies and Bounties: Payments of subsidies and bounties to various sections of the industry have been made from time to time, but such assistance as a stimulus to development would normally be the exception rather than the rule. At present, direct financial assistance is available under certain circumstances to producers of copper, gold, pyrites and sulphuric acid. These can hardly be looked upon as an incentive to new development as basically they are designed to maintain production which otherwise would have to cease, an important consideration being the livelihood of relatively important centres of population.

29. Although the usual approach is to use subsidy and bounty payments to enable existing production to be maintained, the concept of the present subsidy scheme for oil exploration is the eventual development of a new industry. There is no commercial production of petroleum in Australia and the expenditure on imports exceeds that of any other single commodity; the availability of domestic petroleum in times of emergency is also an important consideration.

30. To accelerate petroleum exploration the Commonwealth Government embarked on a subsidy scheme in 1957 to encourage private enterprise. Over the years the form of the Petroleum Search Subsidy Act has changed somewhat but in all cases it has been designed to increase exploration, and to ensure that subsidized exploration is adequately planned, carried out and reported upon and that the results of this work are available a relatively short time after completion.

31. Operations which may be approved for subsidy are: (a) detailed structure drilling and test drilling; (b) drilling, including off-structure drilling, for stratigraphic information; (c) geophysical logging of bore holes (including water bores); and (d) geophysical surveys.

32. The aims of the Government are being substantially achieved. Oil search has increased greatly; at the end of July, 1963, thirty-five seismic crews, ten rotary rigs and two cable rigs were in operation. Though these numbers may be small compared with those in oil-producing countries, they are a very substantial increase on the numbers operating only a few years ago.

33. The total expenditure on oil exploration from all sources to the same date was more than £A80 million and almost half of this was in the Australian Territory of Papua and the Trust Territory of New Guinea. To the end of June, 1962, the Commonwealth Government had paid out about £A5 million in subsidy; an additional £A5 million has been allocated for subsidy for the financial year, 1962/63.

34. International Trade: Because of its control of international trade, the Commonwealth Government is in a position to influence the development of domestic industries that may be dependent wholly or in part on overseas markets or are subject to competition from imports. The principal reasons which may result in export controls being imposed are that: (a) domestic resources are regarded as small in relation to requirements of industry; (b) domestic production is inadequate to

meet internal demand; (c) the further treatment of ores and concentrates internally is considered to be in the best interests of the industry and the economy generally; and (d) there are strategic implications.

35. However, where the emphasis is on development it must not be overlooked that the ultimate stimulus to exploration and expansion is the ability to sell either domestically or on overseas markets. Accordingly, where the day to day needs of the domestic industry are likely to be met from known resources for some time ahead, but these resources are relatively limited, it is almost certain that the exploration for new resources will be retarded if access to export markets is not available. The recent history of iron ore exploration in Australia is a very striking example.

36. In 1938 a complete embargo on the export of iron ore from Australia was imposed and this was retained until 1960. The known resources of high-grade iron ore at that time were relatively small for a rapidly expanding industry and very little new discovery was made during these years. As an incentive to exploration and also to take advantage of the possible development of export earnings from iron ore, the embargo was partially relaxed late in 1960. As a result of this change in policy there was a marked upsurge in interest by private enterprise in exploration for iron ore. Recent discoveries suggest that Australia's resources may well be of world-ranking importance and there seems little doubt that eventually they will form the basis of a worthwhile export industry, at the same time providing adequate supplies for the long-term expansion of the domestic iron and steel industry.

37. In order to maximize export earnings and employment opportunities and increase the availability of important by-products, it is natural for countries exporting basic raw materials to attempt to ensure that processing of these raw materials is carried as far forward as possible before shipment. However there is the obvious possibility of a conflict of interest between exporters and importers, particularly where considerable capacity for processing is already available in importing countries.

38. Notwithstanding the objectives of exporting countries there is no doubt that a very rigid policy of maximum processing before export can, in certain circumstances, present problems. Where a country has in its possession a major proportion of world production, and substitute materials are not readily available, the exporter is in a strong position. But where these circumstances do not exist, or where producer-exporters do not act in concert, the ability to export substantially processed materials could well be hindered and the choice may then rest between exporting ores and concentrates or a very reduced quantity of processed material.

39. Protection of a domestic industry from imports may, if considered necessary, be applied in the form of a tariff. Furthermore, quantitative controls on imports may be applied from time to time but this mechanism is generally invoked as a short-term measure to conserve foreign exchange rather than as a means of conferring protection.

40. Rewards: From time to time financial rewards have been offered for the discovery of certain minerals. The most notable and effective recent reward was that offered for the discovery of uranium ore. This reward, together with a prospector's guide issued by the Commonwealth Government, were instrumental in the timely discovery in 1949 of the valuable uranium ore deposit at Rum Jungle, for which the discoverer

received the maximum reward of £A25,000. Two rewards to the maximum amount and numerous proportional ones were paid for other discoveries. There is no doubt that the reward created a great deal of prospecting by individuals. After the uranium industry was established the reward was withdrawn.

CONCLUSION

41. In the post-war era the Australian mineral industry has gone through a period of continuous expansion. Generally speaking this expansion has been from ore-bodies whose existence had been known for some considerable time and were in various stages of development and production. In recent years there have been a series of new important discoveries some of which are now at the point of coming into production; for others plans are in hand for early development.

42. There has been an important increase in the amount of scientific exploration by Government organizations and industry; and recently, a notable inflow of capital and technical knowledge from overseas mining groups seeking to establish productive operations in Australia. This applies to the base metals and industrial minerals, as well as to petroleum in which this development has been the most important.

43. It is impossible to measure in quantitative terms the actual contribution of Government to these developments. Nevertheless it is fair to say that the mineral expansion programme and the impetus to exploration reflects the confidence of private enterprise in the overall policies and attitude of Government to the task of mineral development.

NOTES

1. Les mémoires choisis pour être présentés en séance générale pourront être obtenus à la Conférence dans les langues officielles suivantes des Nations Unies: anglais, espagnol, français et russe.
2. Les mémoires choisis pour être présentés en séance spéciale pourront être obtenus à la Conférence dans l'une seulement de ces langues officielles.
3. Les résumés qui ont été rédigés pour tous les mémoires par les auteurs de ceux-ci pourront être obtenus à la Conférence dans les langues officielles suivantes des Nations Unies: anglais, espagnol, français et russe.
4. Préalablement à la Conférence, les mémoires et les résumés ne feront pas l'objet d'une distribution générale mais d'un tirage restreint destiné aux délégations des gouvernements et autres participants officiels. La publication et la distribution générale des actes de la Conférence s'effectueront conformément aux règles et pratiques agréées par le Comité des publications des Nations Unies.

LES METHODES MODERNES DE PROSPECTION

par Pierre LAFFITTE, Ingénieur en Chef des Mines
Directeur Général Adjoint du Bureau de Recherches Géologiques & Géophysiques

Il faut distinguer l'emploi de nouvelles techniques ou de nouvelles branches scientifiques particulières, et la méthodologie consistant à faire converger les techniques - anciennes ou nouvelles - vers un même but.

Je voudrais tout d'abord souligner très fortement un point ; la qualité et le modernisme de la méthodologie sont infiniment plus importants que le modernisme des techniques employées. Si l'on n'apporte pas le plus grand soin à réaliser une combinaison intelligente des techniques modernes, celles-ci ne conduisent qu'à des dépenses parfois plus élevées que les méthodes d'antan, avec moins de découvertes.

Géochimistes, géophysiciens, photo-interpréteurs, tectoniciens, géomorphologues, sédimentologistes, tous peuvent dire " Protégez-moi de mes amis, mes ennemis je m'en charge ! ".

Il n'y pas de pire danger pour le développement de la géochimie appliquée à la prospection minière que la géochimie mal employée; pour la géophysique que la géophysique mal employée, etc ... Sans doute était-il inutile de souligner ce point devant cet auditoire. Mon expérience pourtant m'a montré que même des hommes avertis se laissent parfois attirer par ce qui constitue un jouet nouveau.

I - LA METHODOLOGIE

De la méthodologie, que dire ? Nous soulignerons simplement trois points:

a) La notion de groupe de travail (fonctionnels - opérationnels)

En matière d'établissement de programme, l'un des points fondamentaux est la notion de groupe de travail horizontal faisant intervenir des spécialistes par branches scientifiques, par substances et par régions.

Ainsi, pour une prospection systématique d'étain en Bretagne, il sera bon d'établir un programme en commun avec :

- un spécialiste de la métallogénie de l'étain
- un géomorphologue pour l'étude des flats
- un pétrographe pour l'étude des granites.

L'exécution, par contre, restera confiée à un responsable unique, lui-même spécialiste de la région, qui aura participé à l'élaboration du programme et qui devra se sentir le patron lors de cette phase exécutoire.

De tels groupes sont extrêmement variables. ils ne se conçoivent que cas par cas. Mais un caractère permanent demeure : cette méthodologie exige des équipes qui s'entendent bien et qui comprennent la règle du jeu : séparation entre les spécialisations fonctionnelles et les agents d'exécution. Ces derniers peuvent, dans certains cas, avoir une spécialité fonctionnelle; il n'en reste pas moins qu'ils interviendront alors à deux titres différents.

Cet esprit d'équipe est fondamental. L'échec partiel de certaines entreprises montées sous l'égide de l'O.N.U. n'a pas d'autre cause que ce manque d'esprit d'équipe car trop souvent par le passé, on a pu croire qu'il suffisait de rassembler et juxtaposer des experts isolés pour constituer une équipe efficace.

b) Adaptation, dans chaque cas particulier, de la méthodologie employée

Cette méthode cas par cas s'oppose à une méthodologie rigide; souple et flexible, cette façon de procéder repose sur un principe de base :

utilisation permanente de la matière grise pour adapter au but :
découverte des gisements exploitables ou de ressources en eau,
établissement d'une infrastructure géologique, etc .., les techniques et les connaissances qui existent.

Ceci peut prêter à sourire; ceci rappelle par antiphrase la formule très anglo-saxonne : " Ore is where you find it ". " Le minéral est là où vous le trouvez ". On pourrait condenser encore la formule en disant : Le cerveau, instrument essentiel de la prospection moderne. Pourtant, par son appel à la pensée agissante, cette formule montre bien son origine dans la culture issue de Platon et Descartes, culture qu'il est convenu d'appeler méditerranéenne.

Effectivement, si l'on veut adapter la méthode à chaque cas particulier, dans les grandes lignes comme dans les détails, l'emploi des techniques modernes de prospection nécessite l'emploi constant de matière grise individuelle. Si l'on y ajoute la mise en commun sous forme de travail en équipe de cette matière grise, on retrouve : Liberté individuelle et Sens du Social, qui caractérisent le développement au XXème siècle. En France, ces deux notions conditionnent par leur conjonction les particularités des structures organiques (économie concertée, organismes semi-publics, secteurs d'économie mixte avec associations capital privé - Etat) et des méthodes de pensée.

c) Enfin, il convient de souligner que, lorsque dans un organisme, les principes a) et b) existent, et notamment qu'un esprit d'équipe est établi, il s'instaure un climat très particulier, que les sociologues pourraient fort utilement étudier car il ne se résoud pas à d'autres types de groupements humains. Un tel climat de travail est éminemment formateur. Dans les pays en voie de développement, l'existence de l'exemple et la possibilité de la formation technique et morale des spécialistes locaux, jointes à l'exemple vécu et concret d'un climat sociologique actif, vivant et dynamique, sont des facteurs très importants de développement humain, donc multiplient par là même le développement économique.

II - LES TECHNIQUES

Nous ne parlerons pas des techniques telles que la prospection géochimique ou hydrogéochimique, des diverses modalités de l'emploi de la géophysique, de la photogéologie. Elles sont déjà depuis fort longtemps étudiées et il existe de par le monde nombre d'entreprises spécialisées, capables d'exécuter sous forme de prestations de services des prospections sur une surface déterminée. Toutefois indiquons qu'en matière de photo-interprétation beaucoup de progrès sont réalisés ces tous derniers temps, notamment grâce à la méthodologie évoquée ci-dessus, qui permet de rassembler auprès du spécialiste de photo-réinterprétation un groupe de travail comprenant le géologue de terrain connaissant la région, le géomorphologue et le tectonicien.

La prospection géominéralogique

Plus connue sous le nom de prospection alluvionnaire, cette méthode traditionnelle, archaïque même, peut à l'aide du cerveau, instrument essentiel des méthodes modernes, être renouvelée.

Dans sa mise en oeuvre, tout d'abord. Traditionnellement, il s'agit d'effectuer des puits dans les alluvions jusqu'à atteindre le rocher, ou bed-rock, de quarter, de laver à la batée.

Le cerveau peut en élargir le champ : prendre des échantillons du sol et les chauffer la nuit pour y rechercher des grains thermoluminescents de fluorine : c'est de la prospection géominéralogique de fluor. Échantillonner des quartzites ou des grès, les broyer et concentrer des minéraux lourds.

Prélever, après étude géomorphologique, des échantillons dans le lit vif des rivières à quelques décimètres de profondeur, non pas en se déplaçant le long du réseau hydrographique, mais en suivant un itinéraire routier - ou tous terrains - établi sur cartes ou photos d'avion, itinéraire qui touche ou recoupe les rivières ou ruisseaux selon un certain maillage : voilà une méthode qui, par rapport à l'alluvionnaire classique, permet presque de multiplier par 100 la surface couverte pour un prix donné. Il suffit d'un petit nombre d'expériences pour définir les conditions géomorphologiques, le maillage nécessaire en fonction de l'altérabilité et du volume des anomalies minéralisatrices que l'on recherche. Ainsi, dans le cas d'un réseau hydrographique donné, et dans le cas de recherche de gîtes grands et petits (je rappelle que, dans certaines régions, on ne recherche que de grands gîtes, les petits n'étant pas exploitables), on aboutit à une maille correspondant à 1 km en moyenne.

Le prix de revient de la prospection est alors de l'ordre de 17 NF par prélèvement, soit environ 150 000 NF pour 10 000 km².

La métallogénie prévisionnelle

Compte tenu de ce que - en Europe et hors d'Europe - les gisements vraiment évidents sont en grande partie déjà découverts, l'expérience prouve que la recherche aboutit plus vite lorsque l'on sait ce que l'on cherche et où le chercher. Une recherche générale systématique est, dans nos régions européennes tout au moins, une entreprise pour laquelle le succès s'avère aléatoire, lointain et très coûteux. Plutôt qu'un illusoire ratissage absolu, il vaut mieux prospecter un territoire ou une province à multiples reprises, une fois pour uranium, une fois pour de la magnésite, une fois pour de la chromite, une fois pour de l'étain, une fois encore pour de la magnésite avec une autre idée directrice, etc Au cours de chaque prospection, il est bien certain que l'on peut trouver autre chose, mais le cerveau, instrument essentiel des méthodes modernes, sera orienté vers un type de gisement, une substance ou un groupe de substances bien définis. Il pourra fonctionner avec certaines idées directrices au lieu de rester disponible sans idée préconçue, donc sans idée du tout.

Une façon excellente d'avoir des idées préconçues consiste à se pencher sur des cartes géologiques ou des cartes de gîtes minéraux, et d'essayer de faire des cartes métallogéniques prévisionnelles en les gribouillant, les combinant avec des cartes géophysiques structurales, des cartes paléogéographiques. Il s'agit ensuite de laisser guider l'imagination et la réflexion par la carte, ce qui est une technique de travail psychique. Les idées préconçues que l'on se forme ne doivent pas, bien sûr, se transformer en dogmes...

La Géomorphologie est aussi une méthode moderne de prospection d'un emploi de plus en plus fréquent. L'oeil du géomorphologue est exercé de façon différente de celui du prospecteur. Une équipe géomorphologue-géologue minier est un doublet qui voit mieux et plus vite que la somme de ses parties.

Dans d'autres domaines, le doublet sédimentologue-géologue minier ou, de façon plus précise et plus large, en même temps physico-chimiste des sédiments plus géologue minier est aussi une source de progrès. (Nous revenons à notre premier principe méthodologique : l'emploi d'équipes).

Etude de stratégie de la prospection

A un autre pôle, et avec l'objectif de la recherche de gîtes cachés, je voudrais dire quelques mots de la stratégie de la prospection au niveau gouvernemental, ou au niveau des responsables de la politique de recherche. Cette technique particulière est évidemment fondamentale, mais, à ma connaissance, fort peu avancée. Les premiers travaux datent de 1936 (M. Blondel). Actuellement, au B.R.G.M., nous avons un groupe de recherche opérationnelle dont l'objectif est d'adapter à tous les problèmes de prospection, d'études d'indices, de cubage de gisements, d'étude économique, d'équipement de gisements, les moyens modernes de calcul, d'ordinateurs, etc ... La prospection est évidemment, dans ce domaine, la partie difficile.

Le groupe qui réunit géologues miniers, économistes, géophysiciens, géostatisticiens et spécialistes de recherche opérationnelle cherche à définir des possibilités de présence de gisements de certains types en fonction d'un ensemble de caractères et dans certaines zones définies par des critères lithologiques, magmatiques et structuraux. Et, à partir de ces probabilités, par des méthodes tirées de la théorie des jeux, la programmation linéaire, le calcul matriciel avec emploi d'ordinateurs, il cherche à définir des stratégies de la prospection qui rendent optimum les probabilités de découverte.

C'est grâce à ces méthodes auxquelles les déjà traditionnelles méthodes photogéologiques, géophysiques et géochimiques viennent, bien sûr, apporter leur appui que l'on peut valablement effectuer des recherches minières au moindre coût et dans les meilleures conditions et, après avoir prospecté les gîtes affleurants et sub-affleurants, attaquer la recherche des gîtes semi-cachés et des gîtes cachés. A cet égard, rappelons qu'en France la recherche des gîtes cachés n'en est plus à ses essais, mais a déjà plusieurs découvertes à son actif.

**E/CONF.39/
A/303**

**Readex
Fiche**



E/CONF.39/A/303

1 Nov.1962

ORIGINAL : ENGLISH

**UNITED NATIONS CONFERENCE
ON THE APPLICATION OF SCIENCE AND TECHNOLOGY
FOR THE BENEFIT OF THE LESS DEVELOPED AREAS**

Agenda Item: A.5.1

Israel

**ORGANIZATION, PLANNING AND PROGRAMMING
FOR DEVELOPMENT OF MINERAL RESOURCES**

By M. BADER,
General Director of the Ministry
of Development,
Israel

Papers have been contributed to the United Nations Conference on the Application of Science and Technology for the Benefit of the Less Developed Areas as working papers for that Conference. They are published as presented by the contributors, and the contents and the views expressed are those of the contributors. (See notes overleaf.)

NOTES

1. Papers selected for inclusion in General Sessions will be available at the Conference in the following official languages of the United Nations: English, French, Russian and Spanish.
2. Papers selected for inclusion in Specialized Sessions will be available at the Conference in only one of the above official languages.
3. Summaries of all papers, as submitted by contributors, will be available at the Conference in the following official languages of the United Nations: English, French, Russian and Spanish.
4. Papers and summaries will not be available for general distribution in advance of the Conference. They will be published in advance in limited quantities only for the use of delegations of participating governments and of other authorized participants. Post-Conference publication and general distribution of the Conference Proceedings will follow United Nations practices as laid down by the United Nations Publications Board.

Organization, Planning and Programming
for Development of Mineral Resources

Mineral resources have been exploited in undeveloped or under-developed countries to the extent that, more or less accidental, rich deposits were found and that access to them was easy. Generally, these deposits were exploited by foreign companies which possessed the capital and know-how, for purposes of almost complete export of the output of the works. The yield of the minerals was not integrated in the economy of the country, and it did not contribute much to its general industrial and economical development. This fact applies to gold, diamond, copper mines etc. and especially to oil extraction. Under these circumstances, natural resources did not and do not form a basis for the development of the country, but rather a cause for backwardness and subordination.

Natural resources can be fundamental for economic development as well as economic and even political independence in states of under-developed countries when such resources are owned by the nation and their output is not exported in the form of raw material but is utilized as a basis for the development of industries which process and sell finished products.

X

X X

Therefore, the way of planned development in the awakened countries which are making an effort to cover in short time the gap of their economic tardiness is different from the above mentioned. Within the frame of general economic planning, the objectives of the economic policy of the state are determined. The industrial development planning is fundamental and perhaps the most important in the general planning.

It has been pointed out⁽¹⁾ that:

"Industrial development contributes to three important objectives of the countries in the Region (Asia and Far East):

- (i) the achievement of a rapid growth in national income in the near future,
- (ii) increasing the stability of the economy, and
- (iii) the creation of skills and experiences that will in the future lead to a more rapid increase in productivity and a more flexible economy."

The same source⁽²⁾ defines the main objectives of industrial development planning as follows:

- (i) a rapid increase in per capita income,
- (ii) a high level of employment,
- (iii) equilibrium in the balance of payments.

(1) Formulating industrial development programmes. United Nations Economic Commission for Asia and the Far East, Bangkok 1961, p.1.

(2) Ibid., p.10.

The production of minerals fulfils directly a similar task as does industry in general from the point of view of the objectives of planning. Besides of that, it forms a basis for the development of extensive industries based on minerals as raw material.

The most important functions objectives for planning the development of the exploitation of minerals are:

- (i) extensive exploitation of natural resources, both for local needs and for export,
- (ii) assuring the supply of raw material to the developing industry,
- (iii) avoiding the import of raw materials found in the country.

Planning the development of exploitation of minerals and its implementation require specific efforts in various directions.

Let us indicate a few specific characteristics of the mineral sector and its development:

- (i) the development of the sector depends on the existence of minerals at the place;
- (ii) **location** of the works for the production of minerals depends on the site on which the minerals are found;
- (iii) exploitation of minerals which are cheap, heavy and are to be found almost anywhere is limited for local needs;
- (iv) differences of minerals as found in nature require examination and special technical treatment of each mineral;
- (v) it is desirable and sometimes necessary that the industrial processing of minerals be performed at the site;
- (vi) enrichment of the materials and the additional industrial processing improve the feasibility of the exploitation;
- (vii) even though thorough geological and technological research is carried out, the possibility of surprises exists with regard to the quantity, quality and conditions of exploitation of the minerals;
- (viii) the exploitation of minerals requires much time and large investments for geological prospection and technological research;
- (ix) if the minerals are located beneath the surface of the ground and processing is necessary, large sums are required for fixed long range investments.

Planning the development of exploiting the mineral resources forms a sector of the general industrial planning, and therefore a few sectoral laws are applicable. Proper planning necessitates determination of the relationships among all the sectors in the frame of the general industrial planning. However, there is a possibility of separate analysis.

"Industrial planning requires a choice of sectors for development and a projection of demands and supplies in each sector. When there is not much realtion between different industrial sectors, these two types of analysis can be done from information on individual sectors and projects without much regard for development in others."(3)

It should be pointed out that from the viewpoint of the relation between the sectors in the frame of the general planning the approach differs according to the nature of the minerals:

- (i) heavy and cheap minerals: their exploitation is profitable only for local needs and therefore their development should stick to such needs; therefore, a balance between the development of the sector and the parallel development of the sectors consuming the output of these minerals should be striven for,
- (ii) minerals which are of importance in the international market: their exploitation is desirable if the export assures profitable prices; in this case the sector should be developed to the extent of marketing possibilities of the quantities produced.

In both cases, consideration is required within the frame of the general planning (if general planning exists), of the general demands for capital for investment, foreign currency, raw materials, water, electricity, and skilled man-power.

Planning and programming of the mineral sector are similar to other industrial sectors. There is a specificity - the uncertainty existing till the prospectation is not completed and the geological assumptions are not proved in detail. This is also the difficulty confronting long range mineral development plans being in prospectation stage at the time of planning.

The need for long period for geological and technological research should be taken into account when long range planning is made, sometimes beyond estimation in the optimistic assumption.

Technological research is almost always necessary to obtain the data for planning and design. Engineering design, project analysis and criteria for the choice of alternatives and priorities with regard to the development of mineral resources are generally similar to other industrial projects.

It should be emphasized that in the choice of priorities with respect to other industrial sectors, consideration should be given to

(3) Ibid. p.8.

the fact that the mineral sector exploits the local resources and forms a basis for the development of other industrial sectors, and should be therefore preferred over other sectors because of this additional factor. Sometimes, these works are less justified in the light of short range considerations; however, in the long run, they lead to the erection of connected industries which increase the value of the minerals and enlarge the economic feasibility of their exploitation. The costs of general research works and the investments in general development projects in regions where development is foreseen or at a commencing stage, have and must be, therefore, on the burden of the National Development Programme of the country.

X

X

X

Until the recent few years, the mineral sector in Israel was not developed and its part in the State's economy was of no importance. However, in recent years the development was steep. The mineral sector is now playing a role of growing importance in the industrial output and especially in export. The foundation for further extensive development has been laid and it is the source for the development of additional industries. This large and varied development has been achieved by means of the initiative, planning, organization and financing of the government through the Ministry of Development.

It could not be any other way.

Programming and implementation of the development of natural resources in under-developed countries necessitate the active participation of the government, either directly or through special authorities.

To base the development on the initiative of accidental private enterprise, that operates in the light of its private aims to obtain conclusive profits at the shortest interval, would slow down the process of development and its way would not be straightforward.

The development of the mineral sector in undeveloped and under-developed countries ought to start with encompassing geological research in order to determine what natural resources are worth exploiting, parallel technological research to determine means for improvement and industrial processing, design and implementation of projects financed by the government, to the extent that no other factors ready to partake in the pioneering task of development commencement are available.

Fulfilment of these tasks necessitates the creation of appropriate instruments:

- (i) a special governmental authority for planning, implementation and financing of the projects,
- (ii) geological and geophysical research institutes,
- (iii) laboratories and institutes for technological research,
- (iv) development companies for implementing the projects and their

operation.

In 1953 the Ministry of Development was founded in Israel to cope and act for the development of the mineral sector in Israel, and for the development of the Southern Negev.

Even before this, in 1949, shortly after the founding of the State of Israel, the Government established the "Geological Survey of Israel" (G.S.I.) as its agency concerned with all matters pertaining to economic geology in its various aspects. The exploration activities of the G.S.I. have led to the discovery of formerly unknown natural resources which, in turn, led to an expansion of Israel's industrial potential and particularly to the development of the Negev.

In order to fulfil its functions, the G.S.I. is engaged in research in all branches of geology. This work is accomplished through following divisions: geochemistry, hydrogeology, mapping, mineralogy, oil, paleontology, seismology and geomorphology.

Additional to and in connection with this, the Government established in 1957 a specialised institute for geophysical surveys, "The Israel Geophysical Institute", which activity is mainly in the field of water and oil exploration.

The Government of Israel, by itself and with the participation of other public factors, founded development companies for the task of exploiting the mineral resources. In particular, "Israel Mining Industries" should be mentioned, to attend matters of prospection (through the Geological Institute), to perform technological research (in their own laboratories and with the participation of other laboratories), to execute the planning, engineering and erection of mines and plants for the exploitation of the mineral resources.

The company prepared projects for the exploitation of various minerals, developed new technological processes and also erected the copper-cement mine and plant in Timna (which are operated by them on the base of a managing agreement).

X

X X

It is particularly interesting to follow the development of the oil exploration activities in Israel in the light of Government policy in the matter.

Oil exploration in Israel commenced in 1953 in the footsteps of the Israeli oil-law, which permitted oil licenses for areas of no more than 400 sq. kilometers.

These ordinances, based from a geological-scientific aspect on the evaluation that in exploration the structural trap alone should be stressed, were aimed to attract numerous companies to participate in the explorations with a distribution of their risk to a few zones and a number of areas, the characteristics, qualities, and real priorities of which were unknown.

The start turned out to be good, the activity reasonably spread forth and many companies, among them also foreign, participated. The results obtained are not economically negligible. The value of the oil wells and gas deposits found till now surpasses exceedingly the global investment including exploration up to date. But those results did not cope the great hopes, and perhaps therefore most of the foreign companies disappeared from the horizon leaving mainly 3 Israeli companies active, the great part of their capital emanating from Government and public sources.

Accumulated know-how and experience have consolidated the opinion that exploration for layer traps should be stressed. These searches necessitate research in large areas and in regional development scale.

Such prospections should be conducted according to a master plan, by determining priorities and division into research and exploration regions according to the regional scope of the geological problems.

Summarizing the investigations for composing a master plan, with the assistance of a prominent foreign specialist, it was realized that uniting the three oil companies into one national company is a conditio sine qua non to obtain the national objective of the discovery of oil resources and their development according to the needs of the State.

X

X X

The development of the mineral sector is of decisive importance for the development of undeveloped regions and planning their development. The geological prospection is in many cases performed in undeveloped regions or even unpopulated ones. Exploitation of the minerals in the first stage and their industrial processing in the second stage cause employment, the development of roads, ports, railways, electricity and water plants, industrial by-plants and services, including commercial, public and personal services for the workers directly or indirectly employed in these works and their families. The exploitation of mineral resources is the basis for extensive development of the region.

A characteristic example of development of an unpopulated region on the basis and according to the exploitation of mineral resources is the development of the Southern Negev in the State of Israel.

The Southern Negev is an arid region that forms more than half of the area of the State of Israel and which, till a few years ago, was an unpopulated part of the country. However, the Southern Negev forms the main deposit of mineral resources in the State of Israel.

After the establishment of the State of Israel, extensive geological and mineral research work was performed in this region. The results of this research have led to the location of mineral fields which made possible the development of mines and plants for exploitation and industrial processing of these minerals. The Government, through the Ministry of Development, erected in Oron a plant for the extraction of phosphates (~~Negev~~ Phosphates Ltd.), a plant for copper-cement production (~~Israel~~

Mining Industries Ltd.) in Timna and quarries for clays and glass sand extraction in the Big Machtesh, a quarry for extracting various clays and in particular flint clay in Machtesh Ramon (Negev Ceramic Materials Ltd.). The largest and most important plant for mineral exploitation is the plant for potash extraction from the Dead Sea (Dead Sea Works Ltd.), combined with the plant for bromine and bromides extraction (Dead Sea Bromine Ltd.). Additional quarries, where extraction has already commenced, were located: gypsum in Machtesh Ramon, granit in Eilat. Oil and gas explorations were executed and a methane gas deposit was located in Rosh Zohar. A pipe-line transports the gas from the fields at Rosh Zohar to the plants of the Dead Sea in Sdom and new pipe-lines are being layed leading to settlements and other industrial plants in the Southern Negev.

As stated, the development of these works is made with Government initiative, through development companies founded by the Government especially for this purpose and the major part of the finances come from the Government budget.

Development programming of these works for mineral exploitation and industrial processing mingled with development programming of the whole region.

These plants and the workers employed therein formed the basis for building new settlements in the desert: Eilat, Kfar Yeruham, Dimona, Mitzpeh Ramon, Arad; among these Dimona also attracted other industries and its population surpassed 10,000 persons.

A net of roads was built in the region and additional roads are under construction. Most of the load on these roads are minerals. The feasibility of a railway to Eilat is under investigation, a line which will serve mainly for minerals transportation to the southern gate of the country.

The port of Eilat has been developed so as to make possible the export to Asia and East Africa - the minerals form by tonnage 2/3 of the exports through the port of Eilat.

The Ministry of Development prepared still in 1957 a general long-term development plan for the region of the Southern Negev, according to which exploitation and industrial processing of minerals form the backbone of the economic development.

The development of mineral exploitation necessitates not only equipment and buildings but also training a team of skilled engineers, technicians and labourers at new professions with respect to an undeveloped country. Likewise, together with the planning for the erection of the plants, the preparation of such a team should be planned and attended to. This is one of the most difficult problems, for:

- (i) the profession is new in the undeveloped country, specialists and training staff do not exist, a situation that calls for specialists for training staff from abroad;
- (ii) training of experienced skilled people requires much time;

- (iii) regarding underground mining, it is difficult to find candidates to study the profession, which is a difficult one, and the country does not have a tradition in this profession.

Israel was occupied and still is occupied with this problem. To solve it, various steps have been taken:

- (i) miners from abroad were brought to conduct work in the mine and train local miners;
- (ii) courses to train miners were organized;
- (iii) a Mining Engineering faculty was established in the Technion at Haifa;
- (iv) stipends were given out by development plants to students in the Mining Engineering Faculty tied to the condition that after completing their studies they work for these plants.

x

x x

In most cases, an undeveloped country needs technical assistance from outside in planning, erecting plants and their starting operation because of lack of sufficient professional man-power.

The exploitation and industry of minerals are new sectors in the economy of Israel, and indeed for their development, apart from the know-how and technology accumulated in the country, Israel needed also technical assistance from abroad.

One of the contributions of the international technical assistance to the Ministry of Development is the "Technological Advisory Board" in which, apart from scientists, engineers and local professionals, prominent specialists from abroad participated. The committee operated within the frame of U.N. technical assistance. The Technological Advisory Board discussed all questions of development of mineral exploitation and their industrial processing, and recommended ways of development at all stages: prospection, technological research, planning, programming, design, and implementation.

x

x x

Rapid and extensive development of mineral resources is important for the economy of developing countries, and it necessitates the active participation of the Government in planning and programming of development, in organization and implementation. The establishment of research, planning and implementation instruments is required: geological and geophysical research institutes, applied technological research institutes and laboratories, engineering and economic planning teams, development companies for the erection and operation of works. Guidance, coordination and implementation of projects require the existence of a special Government authority having sufficient financial means. Training professional

man-power of all levels is most important: engineers, technicians and professional workers. The technical assistance and international technical co-operation may answer essential questions of the development.

A consistent and active policy of governments of developing countries for the development of mineral exploitation and processing, according to long-range planning, when the ownership of mineral resources and their development is in the hands of the nation, is likely to contribute to the economic and political independence of these countries.

Israel is ready to help other developing countries by what it has learned from its experience in planning, organization and development of the mineral resources sector.

**E/CONF.39/
A/304**



CONFERENCIA DE LAS NACIONES UNIDAS
SOBRE LA APLICACION DE LA CIENCIA Y LA TECNOLOGIA
EN BENEFICIO DE LAS REGIONES MENOS DESARROLLADAS

E/CONF.39/A/304

1 Nov.1962

ORIGINAL : ESPAÑOL

Punto del programa : A.5.1.3

México

LEGISLACION MINERA DE MEXICO SOBRE MINERALES RADIATIVOS

Por Francisco ANTUNEZ ECHAGARAY,
Director Técnico de Exploraciones
de la C.N.E.N., de México

Las monografías presentadas en la Conferencia de las Naciones Unidas sobre la Aplicación de la Ciencia y la Tecnología en Beneficio de las Regiones Menos Desarrolladas constituyen documentos de trabajo de dicha Conferencia. Se publican tal como han sido presentadas por los colaboradores y los puntos de vista expresados en ellas corresponden a los colaboradores. (Véanse notas al dorso.)

NOTAS

1. Las monografías seleccionadas para las Sesiones Generales serán distribuidas en la Conferencia en los siguientes idiomas oficiales de las Naciones Unidas: español, francés, inglés y ruso.

2. Las monografías seleccionadas para las Sesiones Especiales serán distribuidas en la Conferencia únicamente en uno de los idiomas oficiales antes indicados.

3. Los resúmenes de las monografías presentadas por los colaboradores serán distribuidos en la Conferencia en los siguientes idiomas oficiales de las Naciones Unidas: español, francés, inglés y ruso.

4. No se procederá a la distribución general de las monografías y resúmenes con antelación a la Conferencia. Únicamente serán publicadas en cantidades limitadas con antelación a la Conferencia para uso exclusivo de las delegaciones de los gobiernos participantes y de otros participantes autorizados. La publicación con posterioridad a la Conferencia y la distribución general de las actas y debates de la Conferencia seguirán las prácticas de las Naciones Unidas establecidas por la Junta de Publicaciones de las Naciones Unidas.

LEGISLACION MINERA DE MEXICO SOBRE MINERALES RADIATIVOS

por Francisco Antúnez Echagaray

Director Técnico de Exploraciones
de la C. N. E. N., de México

ANTECEDENTES

Ya en la anterior legislación Minera de México, el dominio del Estado sobre el subsuelo había sido consagrado expresamente, de acuerdo con la Constitución Política de los Estados Unidos Mexicanos, expedida en 1917, Artículo 27.

La Energía atómica, corolario el más importante de la 2ª Guerra Mundial, maduró tanto en los Estados Unidos de Norte América, como en la mayor parte de los países del Globo, bajo la forma de monopolios gubernamentales completos y estrictos.

Las razones para esto fueron las siguientes:

- a) Que los ordenamientos fueron concebidos inicialmente en época de guerra, y bajo la influencia de una psicosis universal.
- b) Que dado el desconocimiento casi general de la naturaleza de la energía atómica, ésta fue considerada inicialmente como un elemento secreto y de carácter eminentemente militar, y
- c) Que dada la potencialidad intrínseca de la energía atómica para producir gravísimos daños, si su aplicación quedaba en manos inexpertas o carentes de confianza, exigía un control y una reglamentación estrictas.

En estas condiciones, el 22 de agosto de 1945 el Secretario de Economía del Gobierno de México, expidió una Declaratoria en virtud de la cual se incorporaba a las Reservas Mineras Nacionales los yacimientos de uranio y demás sustancias radiactivas, para los fines a que se refiere la Fracción IV del Artículo 126 de la Ley Minera, es decir, a fin de regular tanto la producción, como la distribución de dichas sustancias, conservándolas inactivas cuando así lo hicieran aconsejables las condiciones del mercado.

Más tarde, el 15 de octubre de 1946, el Presidente de la República, expidió un Decreto reformativo de la Declaratoria anterior con el fin de que las sustancias radiactivas continuaran incorporadas a las Reservas, pero destinadas al propósito que marca la Fracción III del Artículo 126 de la Ley Minera, o sea el de ser explotadas por el Ejecutivo Federal. En dicho Decreto se establecía que los yacimientos de tales sustancias continuarían incorporadas a las Reservas Mineras Nacionales, pero que serían explotadas por el Ejecutivo Federal exclusivamente. Este Decreto imponía la obligación a los titulares de concesiones mineras ordinarias, de dar aviso a la Secretaría de la Economía en caso de que descubrieran algún yacimiento de minerales radiactivos, y de poner a disposición del Gobierno Federal las sustancias obtenidas, mediante la compra-venta de las mismas.

Posteriormente, el 31 de diciembre de 1949, se promulgó la "Ley que Declara Reservas Mineras Nacionales los Yacimientos de Uranio, Torio y las Demás Sustancias de las Cuales se Obtengan Isótopos Hendibles que Puedan Producir Energía Nuclear", publicada en el Diario Oficial del 26 de enero de 1950.

Además de la incorporación de las substancias mencionadas a las Reservas Mineras Nacionales, esta Ley dispone que la explotación de los yacimientos de minerales radiactivos sólo será realizada por el Estado; que cuando los titulares de concesiones mineras descubran la existencia de esas substancias, deberán dar aviso dentro de los treinta días siguientes al descubrimiento, poniéndolas a disposición del Ejecutivo Federal, el que celebrará contrato de compra-venta con los interesados. Se dispone también en esta Ley, que sólo el Ejecutivo Federal podrá poseer, transferir por cualquier título, exportar e importar las substancias de que se trata, así como el Plutonio (Pu-239), y se señalan las sanciones en el caso de infracciones.

Finalmente, el 19 de Diciembre de 1955, el Congreso de los Estados Unidos Mexicanos expidió la Ley que Crea la Comisión Nacional de Energía Nuclear.

El Encuadramiento Jurídico.- Es ante todo necesario puntualizar que en México, dado su interés por la conservación y el mantenimiento de la paz universal, nunca ha existido la tendencia a colocar el desarrollo de la energía atómica, bajo el control militar, antes que el civil.

Las características principales de la Ley de 1955 son las siguientes:

- 1) Los yacimientos de uranio, torio y de todas las demás substancias de las cuales pueden obtenerse isótopos hendibles o materias radiactivas que puedan producir energía, constituyen Reservas Mineras Nacionales.
- 2) La explotación de los yacimientos mencionados, sólo puede ser realizada por el Estado, a través del Ejecutivo Federal, o de la Institución que éste determine.
- 3) Sólo el Ejecutivo Federal o la institución oficial designada por éste, podrá poseer, transferir por cualquier título, exportar e importar las substancias que se especifican en el Artículo 10 de este Ordenamiento Legal, así como el Plutonio (Pu-239)
- 4) Que los titulares de concesiones mineras, cuando en ejercicio de sus derechos descubrieran en ellas la existencia de minerales o materiales radiactivos, deberán de ponerlas a la disposición del Ejecutivo Federal o de la Institución Oficial designada al efecto.
- 5) Se establece en esta Ley la facultad del Ejecutivo Federal o de la Institución designada al efecto, para celebrar contratos de compra-venta con los titulares de concesiones mineras, para la adquisición del uranio, el torio, etc.
- 6) Que la extracción, refinación, procesamiento, comercio y transporte del uranio, el torio y de otras substancias de las cuales puedan separarse, producirse u obtenerse isótopos hendibles, son facultades exclusivas del Estado Mexicano.

Los rasgos esenciales de la Ley que Crea la Comisión Nacional de Energía Nuclear son los siguientes:

- a) Reafirma el concepto de que el Estado, por conducto de la Comisión Nacional de Energía Nuclear, tiene el control de la exploración y explotación de los yacimientos de minerales radiactivos.

- b) Expresa que los materiales atómicos, son siempre Reservas Mineras Nacionales, es decir, en todo caso, propiedad de la Nación. En otros términos, que estos se substraen al régimen de las concesiones mineras, tanto ordinarias, como en Reservas Mineras Nacionales.
- c) Que la facultad que el Artículo 6o. de la Ley que Declara Reservas Mineras Nacionales los Yacimientos de Uranio, Torio, y las demás Substancias de las Cuales se Obtengan Isótopos Hendibles que Puedan Producir Energía Nuclear, concedía al Ejecutivo Federal para poseer, transferir por cualquier título, exportar e importar las substancias especificadas en el Artículo 1o. de esta misma Ley, queda ahora asignada específicamente a la Comisión Nacional de Energía Nuclear.
- d) Que la Comisión Nacional de Energía Nuclear tiene la tarea de llevar al cabo investigaciones en el campo de la física nuclear y las disciplinas científicas y técnicas conexas, y
- e) Que la Comisión Nacional de Energía Nuclear tiene la facultad de conceder permisos particulares para la exportación e importación de materiales nucleares; de equipos para el aprovechamiento de la energía nuclear y para el comercio y transporte de los materiales y equipos atómicos.

Esta Ley fue resultado de:

- I. El reconocimiento del hecho que México no puede quedar al margen de los desarrollos derivados de los grandes progresos técnicos logrados en el campo de la energía nuclear, y de su aplicación a la producción de energía eléctrica.
- II. El deseo de estimular la participación de la iniciativa privada en el desarrollo de la energía nuclear, para obtener así la cooperación y la ayuda del mundo de los negocios.
- III. El propósito de alentar la producción y el uso de la energía nuclear, como fuente futura de poder.
- IV. Fomentar el intercambio internacional de información sobre la energía nuclear.

Rasgos de mayor significación en la Legislación existente.- Ante todo es necesario hacer notar que la Ley que Crea la Comisión Nacional de Energía Nuclear de México, se caracteriza por un enmarque adecuado de organización, asistencia técnica y control nacional con respecto a los usos pacíficos de la energía nuclear.

Los objetivos más sobresalientes de esta Ley, son: vitalmente lograr el desarrollo de México, derivándolo de los adelantos técnicos obtenidos en el vaso campo de la energía nuclear en el resto del mundo; la aplicación de la energía atómica a la medicina, la biología, la agricultura y la industria; el estímulo de la investigación científica y técnica. Además con vista a la conservación de los recursos naturales de la Nación, la Ley que Crea la Comisión Nacional de Energía Nuclear promueve el interés público en la exploración, el descubrimiento, la explotación y el beneficio de los minerales radiactivos (Uranio y Torio) y en la refinación de los productos metalúrgicos derivados de éstos.

Igualmente en los aspectos relativos al fomento del progreso económico, y en la solución del problema energético aparejado a éste, constituye la Ley un control, a la vez que una guía como sistema normativo en el desarrollo y establecimiento de los usos industriales y comerciales de la energía atómica, tales como: la construcción de reactores para la producción de energía eléctrica, y el uso de los radioisótopos, como detectores, en mediciones; en pruebas radiográficas, etc.

En lo que respecta a las medidas de seguridad, la Comisión Nacional de Energía Nuclear desempeña importantes funciones, ejerciendo un control adecuado sobre las actividades conectadas directamente con los materiales atómicos, a fin de que ni directa, ni indirectamente éstos que están destinados primordialmente a usos pacíficos, sean divertidos impropriamente a propósitos bélicos, ya que el riesgo de radiación está tácitamente involucrado en los materiales atómicos. Así pues, la Comisión Nacional de Energía Nuclear, tiene entre sus múltiples funciones la de vigilar por la salud y la seguridad de los trabajadores y la del público en general.

La Ley que Crea la Comisión Nacional de Energía Nuclear establece en el Artículo 7o. claramente su forma de organización, como parte del Poder Ejecutivo Federal, estando integrada por tres miembros nombrados y removidos libremente por el Presidente de la República, de quien dependen directamente. Esta organización de la Comisión, ha brindado la posibilidad de reunir a personas de diferente formación, en la abogacía, la física-matemática y la ingeniería civil, pero de una alta preparación cultural y técnica para abordar con éxito las difíciles e intrincadas cuestiones referentes a la energía nuclear.

Para asesorar a la Comisión en los numerosos y variados problemas a que tiene que enfrentarse de continuo, se ha creado un Consejo Consultivo integrado por miembros, nombrados y removidos libremente por el Presidente de la República, después de considerar las opiniones de la Universidad Nacional, del Instituto Politécnico y de otras instituciones de carácter científico.

Como el uranio y el torio son los minerales básicos, partiendo de los cuales se obtiene el material fisicnoble, y aunque en algunos países estos minerales son de propiedad privada, bajo licencia, en México como ya se indicó, los materiales atómicos son siempre, es decir: en todo caso, propiedad de la Nación; sin embargo, la Comisión Nacional de Energía Nuclear tiene facultades para celebrar contratos con las personas interesadas en la realización de trabajos de exploración y explotación de los yacimientos de minerales radiactivos.

El Reglamento de la Ley determina:

- a) La duración máxima de los contratos.
- b) La compensación que corresponde a los contratistas por sus inversiones y trabajos en la explotación y la forma de liquidar esa compensación, la cual no podrá ser mayor del 75% del valor neto de los minerales extraídos.

Se estipula que los contratos que celebre la Comisión Nacional de Energía Nuclear deberán ser previamente aprobados por el Presidente de la República.

Como uno de los objetivos importantes de la Ley son las investigaciones científicas en el campo de la física nuclear y las disciplinas científicas y las técnicas conexas, la Comisión se ha embarcado en un amplio programa en este sentido, para el desarrollo y adiestramiento de personal dedicado a los procesos nucleares y en los preparativos para la producción futura de energía atómica. Ha puesto también en práctica un amplio programa para la protección de la salud y la se-

guridad de los trabajadores y del público en general. Tiene establecidos cursos sobre los radioisótopos y sus aplicaciones a la medicina, la biología, la agricultura, la industria y el comercio, y para otras aplicaciones pacíficas de la energía nuclear.

La Comisión tiene con otras Instituciones Científicas y Educativas un intercambio constante; elabora programas de educación y adiestramiento; concede, de acuerdo con el Organismo Internacional de la Energía Atómica (O.I.E.A.), becas para la capacitación de técnicos en distintas especialidades de la energía atómica, y actúa a manera de Cámara de Compensación para la reunión y distribución de información, tanto dentro del país, como en la América Latina.



E/CONF.39/A/305

1 Nov.1962

ORIGINAL : ENGLISH

UNITED NATIONS CONFERENCE
ON THE APPLICATION OF SCIENCE AND TECHNOLOGY
FOR THE BENEFIT OF THE LESS DEVELOPED AREAS

Agenda Item: A.5.2.1

Australia

SOME ASPECTS OF EXPLORATION FOR MINERAL DEPOSITS

By B.P. WALPOLE,
K.A. TOWNLEY,
P.R. EVANS,
P.J. JONES,
K.R. VALE,
J. DALY,
N.G. CHAMBERLAIN,
J.H. QUILTY,
R.F. THYER,
F.J.G. NEUMANN,

Officers of the Bureau of Mineral Resources,
Canberra and Melbourne, Australia

Papers have been contributed to the United Nations Conference on the Application of Science and Technology for the Benefit of the Less Developed Areas as working papers for that Conference. They are published as presented by the contributors, and the contents and the views expressed are those of the contributors. (See notes overleaf.)

NOTES

1. Papers selected for inclusion in General Sessions will be available at the Conference in the following official languages of the United Nations: English, French, Russian and Spanish.
2. Papers selected for inclusion in Specialized Sessions will be available at the Conference in only one of the above official languages.
3. Summaries of all papers, as submitted by contributors, will be available at the Conference in the following official languages of the United Nations: English, French, Russian and Spanish.
4. Papers and summaries will not be available for general distribution in advance of the Conference. They will be published in advance in limited quantities only for the use of delegations of participating governments and of other authorized participants. Post-Conference publication and general distribution of the Conference Proceedings will follow United Nations practices as laid down by the United Nations Publications Board.

SOME ASPECTS OF EXPLORATION FOR MINERAL DEPOSITS

by officers of the Bureau of Mineral Resources, Australia.

SEARCH FOR MINERAL DEPOSITS IN UNDERDEVELOPED COUNTRIES¹

1. The prime requirements for mineral search on a national scale are proper planning to make the maximum use of indigenous or acquired sources of technical manpower; the provision of basic materials and data which can be used to localize and control the more detailed and hence more expensive phases of mineral exploration; and adequate funds to equip and man the search. No detailed programme can be presented for 'underdeveloped countries' in general; each country has to be assessed separately. We can only indicate in broad terms the types of techniques likely to be of universal application.

2. Generally, any initial programme of mineral search must be predicated on simple techniques, easily learnt by semi-skilled operators and equipment - sturdy, simple to operate, and easy to maintain. Though some aids to exploration may be given by contractors, the main programme must be so designed that only small numbers of fully-trained scientists are employed. Emphasis is therefore placed on the use of prospectors and on field survey parties of which only the leader need be an experienced geologist.

3. The more important basic materials and data in which most underdeveloped countries are lacking are air-photo coverage, topographic base maps, photogeological maps and reconnaissance geological and geophysical information. All of these can be provided by contractors (the recent provision of photogeological maps to Pakistan by Canada is an outstanding example) and there are numerous firms in the world with proven competence to carry out such work without imposing a drain on local technical resources. Such surveys could also be utilized for training purposes and could provide useful experience for a cadre of scientists from the country being surveyed.

4. In Australia the provision of aerial photography and of topographic base maps is co-ordinated by the National Mapping Council made up of State and Commonwealth instrumentalities and the Army. Priorities are assigned from requests by user organizations, most of which are represented on the Council. Experience has shown that provision of air photographs and base maps before a survey commences leads to very great savings in time and effort.

5. In common with other countries, Australia is now making much use of photogeological maps for mineral search. These are prepared before the main field work in an area commences. The use of a system of transparent photo-overlays and photographic techniques, has led to a marked

¹ Authors; B.P. Walpole and K.A. Townley, Bureau of Mineral Resources, Geology and Geophysics, Canberra, Australia.

increase in the rate of production of geological maps - which, in effect, are revised and refined versions of the photogeological maps. The techniques were first introduced into the country by the Institut Francais du Petrole, operating under contract to the Commonwealth Government, and have been modified to some extent to meet local requirements.

6. The photogeological maps are used for planning and carrying out reconnaissance geological surveys. The 1:250,000 scale adopted for this work is adequate for reconnaissance work and yet allows sufficient detail to delineate areas of interest for potential mineral deposits. For transport in the field full use is made of helicopters, light fixed-wing aircraft and four wheel drive vehicles specially modified for different terrains.

7. Reconnaissance geophysical surveys are adapted to the problem to be investigated. As in other countries, fixed-wing aircraft are used extensively for magnetic and scintillation surveys; and helicopters for positioning geophysicists for reconnaissance ground surveys. The geophysical methods used are standard techniques.

8. To provide reconnaissance information on distribution of metals in mineralized provinces, increasing use is being made of stream sediment sampling techniques. In the arid regions the trend is towards accumulating rock samples in volume from areas of interest and providing laboratory facilities which can cope with large numbers of elemental analyses and yet require only a small technical staff. Non-professional staff are being increasingly used for sampling operations and the laboratory problems are being met by direct-reading spectroscopy coupled with an automatic read-out system. Early surveys, however, could be adequately carried out by large sampling teams feeding samples to field laboratories, in which simple semi-quantitative tests would be undertaken by indigenous technicians under the supervision of a single geochemist.

9. The important role played by the prospector in mineral search is sometimes not given sufficient emphasis. There have been many instances of major discoveries by prospectors in Australia and other countries in recent years - some of these in areas surveyed and rejected by experienced mining companies.

10. At least one mining company in Australia has used the technique of "saturation prospecting" with conspicuous success. It trains its prospectors in general principles, without inhibiting their natural curiosity, and controls their activities only in the geographical sense, through prior photogeological mapping and geological reconnaissance. In countries where inexpensive unskilled labour is available this technique would be most useful, since success in mineral search is commonly in direct proportion to the amount of ground which is examined.

NEW APPLICATIONS OF MICROPALAEONTOLOGY IN AUSTRALIA²

11. Accompanying recent increases in the rate of exploration for oil in Australia, there has been a growing need for adequate palaeontological control of stratigraphy in both reconnaissance

² Authors: P.R. Evans and P.J. Jones, Bureau of Mineral Resources, Geology and Geophysics, Canberra, Australia.

geological mapping and subsurface well interpretation. There are only about seventy five palaeontologists in Australia and most geological surveys are conducted by personnel with little palaeontological training. In consequence, the stratigraphic value of fossil occurrences is not always fully recognized or exploited. Under these circumstances, microfossils, samples for which may be readily and systematically collected from both field and well sections, are more likely to be useful for stratigraphic analysis. The use of Foraminifera is restricted, because many components of the Australian sedimentary basins are pre-Cretaceous in age or of freshwater origin. Most groups of microfossils have been studied at various times in Australia³ but, to assist stratigraphers, the micropalaeontological section of the Bureau of Mineral Resources has specifically directed its attention in recent years to studies of ostracods, conodonts and palynology.

12. Research in each of these fields has assisted not only the Bureau's field surveys, but also the work of commercial oil exploration companies, particularly in the interpretation of Commonwealth-subsidized stratigraphic wells. At present the microfossils are used mainly for local correlation, while research has emphasized the need for additional information about the distribution of the macrofossils by which reference sections have been dated. However, these groups are filling gaps in our knowledge of the Australian stratigraphical column and are supplying their contributions to the search for oil.

13. Stratigraphical results have been published⁴ of research into ostracods of the Fitzroy and Bonaparte Gulf Basins of Western Australia, while study is continuing of conodonts of the central Australian Amadeus and Georgina Basins and of the palynology of the eastern Australian Great Artesian Basin.

14. During the past year, studies of conodonts from Cambrian and Ordovician limestones of the Georgina and Amadeus Basins have indicated that many of these fossils are conspecific with North American and European forms, but it cannot be assumed that they have the same time-range in all three continents. Research, therefore, aims firstly to establish the conodont sequence in relation to trilobite and brachiopod faunas known to other Bureau palaeontologists, and secondly to test their zonal value.

15. So far, conodonts have been found in eight successive horizons from early Middle Cambrian to early Upper Ordovician. The sequence in neither the Georgina nor the Amadeus Basins is yet complete, but they supplement each other in the Lower Ordovician and further collecting will probably fill the gaps. Distinctive conodonts in the Upper Cambrian of the Georgina Basin⁵ show that they are potentially useful for correlation of Cambrian rocks and provide a means of distinguishing the Ordovician from the Cambrian.

³Crespin, Irene, Microfossils in Australian and New Guinea Stratigraphy. J. & Proc. Roy. Soc. N.S.W., 92, 133-147 (1959).

⁴Jones, P.J. Ostracod assemblages near the Upper Devonian-Lower Carboniferous boundary in the Fitzroy and Bonaparte Gulf Basins, App. 3 in Geology of the Canning Basin by J.J. Veevers and A.T. Wells, Bur. Min. Resour. Aust. Bull., 60 (1962).

⁵Jones, P.J., Discovery of Upper Cambrian conodonts in Queensland, Aust. J. Sci., 24, (3), 143 (1961).

16. The Great Artesian Basin of eastern Australia consists of Mesozoic rock unconformably blanketing strata of Precambrian to Upper Palaeozoic age. Oil exploration in the basin has continued since 1900, when gas was discovered at Roma, Queensland. Hydrocarbons occur towards the base of the Mesozoic - as at Roma - or entombed in basins under the Mesozoic blanket. Wells have to penetrate most of the Mesozoic to reach target horizons, but "classical" palaeontological control of stratigraphy in the basin is available only in the marine Lower Cretaceous and sections of the Permian. Systematic palynological examination of the Basin commenced in 1958. By 1961 a provisional spore-distribution/time framework could be constructed from well sections scattered across the Basin as a guide to correlation. Permian and Cretaceous microplankton were also useful in the absence of other marine fossils. Almost the whole sequence from the base of the Permian to the Upper Cretaceous has been examined, although reference sections, dated by other fossil types, had to be obtained from areas outside the Basin.

17. Development of this framework is governed by the economic needs for elaboration, but it also stands as a possible basis for later research in areas where the geology at present is less certain.

RECONNAISSANCE GRAVITY SURVEYS, USING HELICOPTERS⁶

18. In the search for oil in Australia, geophysical methods of reconnaissance are necessary over most of the sedimentary basins because rock outcrops and drill holes are few and consequently normal geological mapping is difficult. Reconnaissance gravity surveys are being carried out by the Bureau of Mineral Resources, Geology and Geophysics. By using helicopters for transport, large inaccessible areas can be covered rapidly.

19. For the purposes of this paper a reconnaissance gravity survey is defined as a survey with observation stations of a sufficient density and accuracy to delineate the broad regional features in the gravity pattern and to elucidate, in so far as Bouguer anomaly can do so, the major units or provinces of a sedimentary basin. The object of this type of survey is to determine the regional structure of the sediments and to define geological provinces suitable for more intensive methods of investigation. The method is considered as a supplement rather than an alternative to aeromagnetic surveys.

20. A 7-mile by 7-mile grid of stations is an acceptable minimum station density, with additional stations where necessary. Anomaly relief of less than 5 mgal is not considered significant for this class of survey.

21. In the one operation the values of gravity, altitude and station co-ordinates are obtained with a time interval of 12 to 15 minutes between stations seven miles apart. A small commercial gravity meter and precise microbarometers are used for the gravity and elevation measurements and station locations are pricked on to airphotos.

22. Helicopters are an expensive form of transport and the operation must be planned carefully to obtain maximum efficiency. They require considerable maintenance, particularly when operating in remote and

⁶Author: K.R. Vale, Bureau of Mineral Resources, Geology and Geophysics, Melbourne, Australia.

dusty regions and allowance must be made for unserviceability; in the Bureau's surveys to date, 25% unserviceability has been assumed for planning purposes.

23. There are a number of advantages in using two helicopters in the one operation. They work from the one base camp in adjacent areas. If one helicopter becomes unserviceable its crew is available to increase the utilization of the second aircraft; also, in the event of a forced landing the second machine is available for immediate rescue work. The Bureau has adopted the two helicopter operation for the above reasons and also because the increased helicopter utilization results in an overall reduction in the cost per gravity station.

24. Within a survey area flights are looped. Common stations are established with previous flights, and ties are made to base stations to control diurnal variations and instrument drift and to permit the distribution of errors. Stationary barometers are read at one or more base stations to establish the diurnal corrections for the traversing barometers. Radio contact is maintained constantly between the base station and the traversing aircraft.

25. In order to provide datum levels and permanent marks for re-occupation on any subsequent surveys, a network of base traverses is surveyed in advance by conventional ground methods. Generally these traverses are north-south and about 50 miles apart, with altitudes to third-order accuracy at bench marks approximately five miles apart. All the gravity data are reduced to a common gravity datum by ties to the national network.

26. There are two basic types of flight planning at present in use by the Bureau. These are termed the "Line Method" and the "Cell Method". In the Line Method, the helicopter works over the survey area in a series of parallel lines at appropriate distances, while in the Cell Method, the survey area is divided into several approximately square "cells", each of which is covered by the helicopter flying routes radiating from a central point. The cell method should provide better instrument control and consequently more accurate results than the line method; otherwise, there is not much to choose between them. The flight time involved is some few per cent in favour of the line method, but better helicopter utilization may result from the smaller flight units of the cell method.

27. Immediately on return of a helicopter to the main base camp, preliminary altitudes are computed for each new station. All station locations are transferred from the aerial photographs to the final base map. From this, latitudes are taken and preliminary Bouguer anomalies calculated. Preliminary contours are then drawn and flights for extra stations planned.

28. The results of reconnaissance gravity surveys are prepared in a series of maps at 1:250,000 scale, showing observation stations, elevations and Bouguer gravity values. The gravity values are usually contoured at 1-mgal intervals. The use of this interval is debatable because the standard deviation in Bouguer anomaly value is, under the most unfavourable conditions, about 2 mgal; the errors arise almost entirely from inaccuracy in altitude measurement. However, under favourable conditions the standard deviation may be as low as 0.5 mgal.

29. The regional gravity maps prepared from the Bureau helicopter

project are a useful contribution to oil search and are much sought after. At present approximately 150,000 square miles are being surveyed each year but a substantial increase in this rate is under consideration. The overall cost of the operation is about 12/- (Aust.) per square mile, excluding the cost of the basic ground traverses.

AEROMAGNETIC SURVEYS IN MINERAL EXPLORATION⁷

30. The aeromagnetic method is used extensively in Australia to assist in exploration for petroleum and metalliferous deposits. It is particularly applicable to regional reconnaissance surveys because of the speed of operation and ability to survey difficult terrain or water-covered areas. Direct detection of deposits of magnetic minerals such as iron ore is possible, but generally the main application of aeromagnetic surveys is to indicate areas that warrant more detailed exploration by ground geophysical methods.

31. The Bureau of Mineral Resources uses a DC.3 aircraft equipped with fluxgate magnetometer and the usual ancillary recording and navigation equipment. Flight lines are positioned either from air-photos or by Shoran; they are spaced $\frac{1}{2}$ to 1 mile apart over metalliferous regions and 1 to 5 miles apart over sedimentary basins. The reduced magnetic data are finally presented as total-intensity contour maps usually at a scale of 1:125,000 to 1:250,000.

32. In interpreting aeromagnetic data it is essential to study the data in relation to known geology. A purely qualitative approach yields information on geological boundaries, structural features and regional trends. The interpretation can be carried further by various quantitative methods which involve detailed analysis of individual anomalies and allow estimates to be made of the depth and configuration of magnetic bodies and susceptibility contrasts. From surveys over sedimentary basins, depths to the crystalline basement and hence the variations in thickness of the sedimentary rocks are determined. The following paragraphs describe three typical examples of aeromagnetic surveys in Australia.

33. A survey of the Perth Basin in Western Australia confirmed the existence of a deep trough of sediments overlying Precambrian crystalline basement. The survey showed the main structural features of the Basin including its off-shore extension; it also showed subsidiary basement ridges within the trough, and the presence of basalt flows within the sediments.

34. On the Precambrian Shield in the region of the Yilgarn and Coolgardie goldfields of Western Australia, aeromagnetic surveys have provided much new information on the regional geology in areas where soil cover makes normal geological mapping difficult. The magnetic contour patterns delineated areas of basic metamorphic rocks, which are common host rocks for gold deposition, and showed as conspicuous magnetic features the presence of banded iron formations with which, in places, iron ore deposits are associated.

35. A survey of iron deposits in rugged terrain in north-western Tasmania recorded extremely intense anomalies that indicated the location and extent of magnetite deposits. This permitted the planning

⁷ Authors: N.G. Chamberlain, and J.H. Quilty, Bureau of Mineral Resources, Geology and Geophysics, Melbourne, Australia.

of detailed ground magnetometer surveys which, together with drilling tests guided by the ground magnetic results, have proved substantial iron ore reserves in the Savage River area.

GEOPHYSICAL PROSPECTING FOR DEEP LEADS⁸

36. Alluvial deposits, known as deep leads, have yielded a considerable production of tin and gold in Australia. These deposits arise from the weathering of mineralized rocks. Minerals such as gold or cassiterite, which are resistant to the chemical processes involved in weathering and are also considerably denser than the ordinary rock-forming minerals, are concentrated by alluvial action on the beds of streams. The stream channels are gradually filled with detrital or volcanic material.

37. In the course of time, stream courses may be changed by geological processes such as tilting, so that the present drainage pattern may be very different from what it was when the valuable minerals were concentrated. In such cases, there is little or no surface indication of the position of the old channels. They must be sought by boring. However, this is an expensive process, requiring highly skilled drillers. Also, the results may be ambiguous or even misleading, owing to the presence of large unweathered boulders in the filling of the lead. There is therefore a considerable advantage to be gained if it is possible to detect the positions of the leads by geophysical methods.

38. A vertical section at right angles to the course of the lead will show the following succession: (a) filling, consisting of detrital material and possibly basalt, which may or may not be completely weathered. The filling may contain valuable minerals, either disseminated or in secondary concentrations on "false bottoms"; (b) wash, with the main concentration of valuable minerals; (c) weathered bedrock; and (d) unweathered bedrock.

39. For geophysical methods to be effective, it is necessary that there should be a clear differentiation in physical properties between the bedrock and the filling of the lead. There are two possibilities that can be exploited: the detrital and weathered material in the filling may be less dense than the unweathered bedrock, or the elastic properties of the unconsolidated filling may differ considerably from those of the unweathered bedrock.

40. The first possibility provides a basis for the application of the gravity method and the second, of the seismic method. However, if the filling of the lead consists of massive rock such as unweathered basalt, the above differentiation in physical properties will be much reduced. Massive basalt does not differ greatly in density and elastic properties from many other types of rock. Therefore, if the filling of the lead consists mainly of unweathered basalt, the application of geophysical methods is much more difficult; in many cases is impracticable.

41. Other methods, such as the resistivity method and in special cases, the magnetic method, have been applied to deep lead problems. However, they are neither so convenient to use, nor capable of giving such specific results, as the seismic and gravity methods.

⁸ Author: J. Daly, Bureau of Mineral Resources, Geology and Geophysics, Melbourne, Australia.

42. As described above, the wash containing the valuable minerals lies on the weathered surface of the bedrock. The surface at which the main discontinuity in physical properties occurs, however, is the unweathered bedrock surface, and it is this surface which can be observed by geophysical methods. So that the results of geophysical surveys may be of economic value, it is necessary that some relation should exist between the contour of unweathered bedrock and the position of the wash. This is not always the case. Two types of false indication are possible. Firstly, if the lead is wide, the wash may be concentrated, on the weathered surface, in a meandering channel which has no counterpart on the unweathered surface. In this case, geophysical methods would fail to indicate the presence of the channel. And secondly, it cannot be assumed that weathering of the bedrock is uniform. Owing to non-uniform weathering, geophysical surveys might indicate, on the unweathered surface, the presence of a channel which does not exist on the weathered surface.

43. The type of lead offering the best prospects for geophysical surveying is a relatively narrow channel with well-defined sides, and with a filling comprised of detrital or completely weathered material. The presence of massive unweathered basalt in the filling greatly reduces the possibility of successful results. If the lead is wide, this fact will be indicated by the surveys, but the results are not likely to give reliable indications of any channels carrying wash. However, if the lead is narrow and well defined, its course can be followed accurately and very little boring is necessary to test it.

44. The soundness of the above contentions has been thoroughly tested by surveys in Australia. In particular, it is found that the gravity method is a convenient means of reconnaissance surveying and, in some areas, is capable of giving more useful results than the seismic method. The magnitude of the gravity anomaly to be expected from a particular lead may be estimated roughly, as experience shows that the densities of the lead filling and weathered bedrock are generally less than that of the unweathered bedrock by about 0.6 g/c.c.

GEOPHYSICAL METHODS IN THE INVESTIGATION OF COAL DEPOSITS⁹

45. Extensive geophysical surveys have been made in Australia to investigate coal resources. The gravity method has been found particularly useful, either to investigate known coal deposits or to trace hidden coal seams. The applicability of gravity methods to mapping coal basins depends on the fact that the coal measures are generally lighter than the basement rocks on which they rest. In many places this density contrast may exceed 0.5 g/c.c.

46. The seismic method of prospecting is generally too expensive to use to any large extent in coalfield investigations. However, special problems may warrant its use; for example at Oaklands, New South Wales, seismic refraction results were used to provide data for estimating the regional gravity pattern. Also it was found that the coal measures had a characteristic velocity, which could be used to map their distribution. Seismic reflection techniques have been used in the Latrobe Valley where the structure of the coal seams can be determined. Seismic methods are likely to be used increasingly in the Sydney Basin for mapping the structure of the coal seams.

⁹ Authors: R.F. Thyer and F.J.G. Neumann, Bureau of Mineral Resources, Geology and Geophysics, Melbourne, Australia.

47. The East Gippsland Basin near the south-eastern corner of the Australian continent contains enormous reserves of Tertiary brown coal, mainly in the Latrobe Valley. The coal, which is of low grade, occurs in several seams with an aggregate thickness exceeding 1,000 ft.

48. Tertiary sediments, which are mostly unconsolidated and include coal seams, are bordered to the north and south by outcropping Jurassic rocks and Tertiary basalt (Figure I.). The coal occurs in a number of thick seams which are almost entirely concealed by sand, clay and gravel.

49. The gravity method is applicable because the Tertiary sediments are much less dense than the basement rocks on which they rest. Correlation of the gravity anomalies with known geology shows that the anomalies are caused mainly by the density contrast between the Tertiary brown coal measures and the underlying Jurassic and Palaeozoic rocks.

50. Gravity surveys have been carried out over approximately 1,500 square miles in the Latrobe Valley and adjacent areas, and the results over part of the area covered are shown on (Figure I), on which the gravity anomalies can be compared directly with the major geological structures. The most obvious correlation is that between the thickness of the Tertiary sediments and the gravity deficiency. The Tertiary sediments correspond to an area of negative Bouguer anomalies whereas the outcropping Jurassic rocks and Tertiary basalt coincide with areas of positive gravity anomalies. It will be seen that the trend of the gravity contours closely parallels the trend of the known geological features. Faults and monoclines (which probably overlie faults in the basement rocks) are clearly shown by zones of relatively steep gravity gradient.

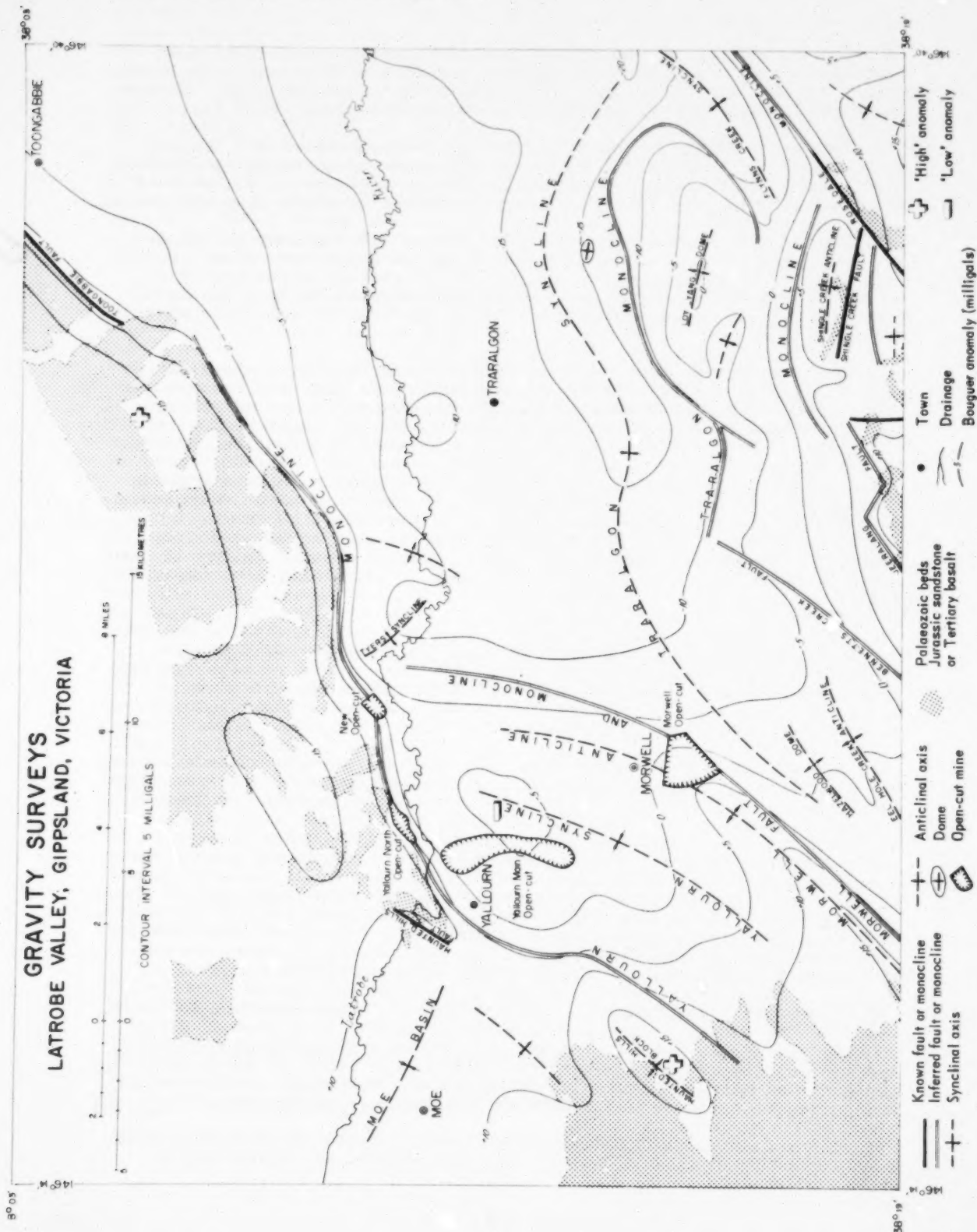
51. Of particular economic interest are the Morwell Anticline and the Loy Yang Dome, which are clearly portrayed in the gravity contours. On these structures, thick coal seams have been proved beneath shallow overburden. A major open-cut has been developed on the northern plunge of the Morwell Anticline and the Loy Yang site will no doubt also be developed when it is needed.

52. The gravity results have been of considerable value in determining the geological structure so that drilling could be carried out to best advantage. A good example of the use of the gravity data for this purpose is provided by developments along the northern edge of the valley. Hard brown coal of better quality had been mined from the Yallourn North open-cut. Coal in this seam was originally considered to be an isolated block because early exploration drilling had failed to find any extensions of it. This is perhaps not surprising when it is realized that this coal seam, although in places more than 200 ft thick, occurs mainly on a steeply dipping monocline. Bores must therefore be very accurately placed to intersect the coal, which is irregular and at places intersected by folds and many minor cross-folds.

53. After the initial gravity reconnaissance it was realized that the monocline is clearly shown in the gravity results by a zone of steep gravity gradients. Detailed gravity surveying was extended eastward, and the results revealed a comparatively narrow trend of steep gravity gradients similar to those obtained over the monoclinical feature with which the coal seam is associated in the Yallourn North open-cut.

54. The zone of steep gradients was shown to continue east and north-east for at least nine miles. It was interpreted as indicating an

extension of the monocline and, by inference the associated coal seam was expected to be present over this distance at relatively shallow depth. Drilling based on this interpretation proved that the coal seam did extend in this way and additional reserves exceeding 100 million tons have been proved.





E/CONF.39/A/306

1 Nov.1962

ORIGINAL : ENGLISH

UNITED NATIONS CONFERENCE
ON THE APPLICATION OF SCIENCE AND TECHNOLOGY
FOR THE BENEFIT OF THE LESS DEVELOPED AREAS

Agenda Item : A.5.2.2

Brazil

THE DEVELOPMENT OF A SMALL
TO MEDIUM IRON ORE MINE

By Oscar de OLIVEIRA,
Director, Cia. Vale do Rio Doce

Papers have been contributed to the United Nations Conference on the Application of Science and Technology for the Benefit of the Less Developed Areas as working papers for that Conference. They are published as presented by the contributors, and the contents and the views expressed are those of the contributors. (See notes overleaf.)

NOTES

1. Papers selected for inclusion in General Sessions will be available at the Conference in the following official languages of the United Nations: English, French, Russian and Spanish.
2. Papers selected for inclusion in Specialized Sessions will be available at the Conference in only one of the above official languages.
3. Summaries of all papers as submitted by contributors, will be available at the Conference in the following official languages of the United Nations: English, French, Russian and Spanish.
4. Papers and summaries will not be available for general distribution in advance of the Conference. They will be published in advance in limited quantities only for the use of delegations of participating governments and of other authorized participants. Post-Conference publication and general distribution of the Conference Proceedings will follow United Nations practices as laid down by the United Nations Publications Board.

THE DEVELOPMENT OF A SMALL TO MEDIUM IRON ORE MINE

by Oscar de Oliveira
Director, Cia. Vale do Rio Doce

1 - BRAZILIAN IRON ORES

- (a)-The principal and best-known iron ore formations in Brazil are the deposits in the "Quadrilátero Ferrífero", the "Iron Quadrangle" in Minas Gerais, covering an area in excess of 6 000 sq km and containing over thirty billion tons of iron ore of various types and qualities. The very valuable work of general geological reconnaissance was undertaken in the last fifteen years by Brazil's National Department of Mineral Production (DNPM) and the United States Geologic Survey team, supported by Point IV (a). A large amount of detailed study remains to be done for future generations of geologists and mining engineers.

The ore is commonly divided into the three principal classes: soft itabirite, hematite and canga. The hematite is classified into hard and soft hematite. The soft itabirite contains anywhere from 35% to 65% Fe and its major and only significant impurity is quartz. This ore is not yet a commercial ore, requiring extensive beneficiation to eliminate the quartz and raise the Fe tenor to over 65%. However, due to its unlimited reserves and easy mining, the itabirite will certainly become a commercial ore in the very near future. An active research for economical processes has been under way for the last four years.

The high grade hematite is of quite uniform quality and ranges in tenor from 66 to 69% Fe. Quartz and sometimes alumina are the only important impurities. The phosphorus content is usually below 0.05 percent. The hematite, both soft and hard, is presently the only export ore ranging in price FOB Brazilian Port from \$7 to \$12. The "canga" is a porous and resistant ore usually found at the surface and is derived from the weathering of itabirite. The average thickness may vary from 1 to 10 m. The Fe content ranges from 45 to 65%, with impurities of silica, alumina and phosphorus. The latter impurity (over 0.1%) prevents its use as export ore unless blended with other ores, but is being consumed domestically in charcoal blast furnaces.

(a) DNPM and USGS, "Outline of the Geology of the Quadrilátero Ferrífero, Minas Gerais, Brasil" (DNPM, Rio de Janeiro, 1959).

- (b)-Most of the 7 000 000 tons of Brazilian iron ore exported in 1961 is compact hematite with reduced amounts of fines (generally less than 25% under 1/2"). These ores, classified according to gradation into lump, pebble and rubble, will gradually become a minor portion of export ores, as cheaper maritime transportation will undoubtedly bring the cost of fines and run-of-mine ores down to competitive levels.

The major ore exports are handled through the ports of Vitória (over 5 000 000 Tons) and Rio de Janeiro (1 100 000 tons). The ore, ship-loaded at Vitória, is mined and transported from Itabira, 570 km inland over a narrow-gage rail by the Cia. Vale do Rio Doce. This company is a corporation with a majority participation (90.7%) from the Federal Government of Brazil, and the remainder 9.3% from private investors. At the present time the following ores are being mined and sold

		% Fe	% P	Humid. %	Grad.	vers. %
L	Lump	68.5	0.045	1	8 x 1/2	10
LS	"Special"	68.5	0.045	1	8 x 2	20
RM	Run-of-mine	64-67	0.05	2-4	8 x 1/2	40
P	Pebble	64-67	0.05	2-4	3 x 1/2	25
G	Gravel	64-67	0.05	6	3 x 1/2	60
F	Fines	60-67	0.08	3-6	1/2 x 0	-

Although on the surface the physical layout of ore mines are very similar to those in other countries, the problems to be faced in Brazil are quite different. These problems and the attempts to overcome them are the basic subject of this paper.

2 - FACTORS AFFECTING MINING OPERATION

The efforts of the Brazilian Government and industry, especially in the last decade have resulted in a very rapid rise of industrial capacity, degree of mechanization and the use of modern technology. The Brazilian manufacturing and service industries present an extreme range from highly mechanized, sometimes automated operations to the most primitive processes using century old manual methods. The phenomenal growth in industry capacity, however, has not been accompanied by a parallel increase in labor ability and capacity. The basic requirements for a compatible educational level and physical state of health of personnel imposed by the more complex technological demands have not been met in the same proportion as these technological advances. Specifically, the divers problems facing the Vale do Rio Doce in its mining and transport operations of iron are as follows:

- (a)-Labor: the distance of the ore body from industrial centers and situated in a relatively virgin and inaccessible region reduces the local availability of labor to practically nil. This is not an uncommon problem for mining operations, as it is the rule rather than the exception that locates the high grade

deposits in faraway undeveloped interiors (b). It becomes therefore necessary to construct new townsites, provide social services and amenities to attract imported labor and prevent too large a turnover. However, the planning for a long-range operation must include the evaluation of labor capability and efficiency, and more important the probable rate of improvement of the labor capability and efficiency in the next 5, 10 and 20 years. The increase of literacy and skills whether caused by the general regional improvement of educational standards or Company-induced schooling and training facilities, must be taken into account not only in the progressive mechanization of mining operations, but phased into the proper depreciation and obsolescence schedule of equipment. It can be said without fear of contradiction that completely unskilled labor is in oversupply and per-man-cost is about \$30 monthly. It is also true that this labor performs with low efficiency in anything but simple and manual operations. This situation is not helped by the shortage of intermediate supervisory skilled labor and foremen, capable of controlling and instructing a large unskilled labor force. And finally the scarcity of experienced technical and managerial personnel intensifies the organizational problems.

(b) Equipment - Until fairly recently, all equipment and tools were imported over a long distance from the U.S. and Europe. As Brazilian industry increases its output from small tools to medium size equipment, and is now initiating the manufacture of heavy equipment, the selection of mining equipment, parts inventory, becomes more and more a critical part of the operations. With an all manual-labor operation the continuity of ore supply is rather constant and risk of breakdown is minimum, and deficient production can be made up by additional labor and small tools. However, considering an average manual production of 8 to 12 tons per day laborer, the capacity of ore production soon reaches a limit as working space runs out and the social obligation of providing decent subsistence becomes overwhelming. Therefore mechanized mining becomes mandatory whenever the annual production of a single mine exceeds say 500 000 T.

(c) Market distance - The principal markets of our iron ore is Japan, Europe and the United States, all in the Northern Hemisphere. In addition to the long maritime distances, the mining districts themselves are located 570 km away from the port, thus imposing on the Company a railroad operation of major magnitude. This inherent handicap can be overcome only by improving bulk transport methods and high-efficiency operation in order to lower the costs to competitive levels. It becomes thus principally a technical problem of increasing transport capacities by better and more powerful traction, longer trains, larger loading facilities and finally the employ of super-carriers. The dimensional increase of cars, trains and ships is compatible with the Brazilian labor situation, as the substantially same number of skilled operators properly trained can handle equipment of larger capacities.

(d) Capital Investment - The requirements for capital in an industrially expanding country can rarely be met by the internal money market exclusively. This problem is not native nor particular to Brazil, but is extremely acute due to

(b) Orinoco, Seven Islands, Cartier, Toquepala and many others.

the economic-political situation, which is not conducive at the present time for large scale private foreign investments. The inflationary economy and the limitations of legislation have made expansion capital rather scarce.

3 - ANALYSIS OF A MINING OPERATION

It will not be asserted here that the solutions for the above-cited handicaps have been found, nor that the manner in which the problems are being treated is the final and absolute answer. This paper will describe the past and present attempts in using modern science and technology for the improvement of a part of Company's operations.

- (a)-Present Mining Operations - The Vale do Rio Doce is presently operating and opening up for operation five iron ore deposits spread over 8 km. More are scheduled over 50 km away. The ore body reserves per mine range from 100 000 000 T to about 30 000 000 T and the production rates range from 3 000 000 T down to 600 000 T annually. The ore mined is all hematite, from hard, compact and abrasive to soft, powdery ores. The ore bodies vary greatly in geological characteristics, homogeneity and iron tenor. The consumers, all non-captives, require specific gradations in variable quantities. The compliance of these various needs require strenuous coordinated efforts of mining, stockpiling, loading and transporting via the railroad to the port, the right quantities of ore, in such a manner that the ore-carriers can be loaded promptly and with the specified ores.

In the earlier years, when quantity and diversity of ore types were reduced, the entire operation can be based on a relatively few skilled operators and managerial personnel. However, the ever increasing production and sales, coupled with the corresponding lack of required additional experienced personnel compelled us to resort to other means to circumvent technician shortages.

- (b)-Specific Problems : In order to operate the company in a competitive market, the management must be able to:
- (i) - obtain exact information on all company's operations immediately, such as stockpile quantities, types of ore, loading requirements, train scheduling, etc.
 - (ii) - react to changes of market demand quickly by modifying mining, beneficiation and transporting operations.
 - (iii) - synchronize all mining operations at optimum level, i.e. by not permitting each separate mine to pursue a course of action which might be the most desirable for it, but instead determining the most profitable operation for the integrated mining system.
 - (iv) - provide technical and operational assistance rapidly and economically, such as proper equipment selection.
 - (v) - maintain up-to-date cost data and surveillance over all operations, to determine the best cost-price relationship and production quantities.

(c)-Flexibility - The multiple operations, as stated above, require flexibility of a large degree. At the same time equipment will last for a certain determined period thus resisting radical changes in operations. And again, labor, due to the slow process of up-grading, will naturally resist quick changes in operations. Consequently the necessities become rather obvious:

- (i) - Equipment, at the expense of individual efficiency, must be standardized to a greater degree, than may be indicated in Europe or the U.S. Interchangeability of parts and components will reduce inventory and abate the pressure for more skilled mechanics and operators.
- (ii) - Central stores, to effectively control and reduce the amount of inventory.
- (iii) - Training centers to provide instructions for operators of more complicated equipment, supervisory and future management personnel.

(d)-Computer : High speed electronic computers can be effectively used to overcome at least a part of the deficiency of technical personnel. The application of the linear programming technique to the solution of our problems is considered one of the best and most versatile technique capable of evaluating alternative courses of action. The linear programming approach permits systematic determination of the best optimum combination from a large number of alternatives and is characterized by high computational efficiency. Therefore the programming formulation can be readily used to develop an array of optimum plans for mining, transporting, loading and selling, covering a whole range of foreseeable conditions. For the analytical study of the existing operations the mathematical description of the individual functions and their interrelations serve to provide a frame work for investigating how the operation would react to variations of different internal and external factors, such as cost fuel, labor cost or sale price of ore, etc. Most of the problems involve the selection, utilization and scheduling of equipment, materials and shipment in order to achieve minimum operating costs, optimum equipment combinations, maximizing profits, optimum ore mix for maximum profits.

4 - PROGRAMMING AN ORE MINE OPERATION ON A MEDIUM-SIZE DIGITAL COMPUTER

(a)-Purpose - The establishment and operation of an ore mine involves a complex of many linear programming type problems and comprises:

- (i) - Formulating the problem and
- (ii) - Performing the detailed arithmetic computations.

The latter eliminates the task of performing the many necessary detailed calculations. Step (i) still requires the use of a trained and experienced technician to develop the following data:

- a - flow chart presentation of the operation.
- b - establishment of a known definable objective or criteria, i.e. grades of ore, quantities, market requirements, etc.
- c - define all restrictions and limitations on the extent of the problem, involving gathering of all data, identifying all variables, their respective coefficients of physical or economic nature.
- d - express the objective function in algebraic form terms of unknowns with explicit coefficients. Then, express the limiting functions in terms of the same unknowns as in the objective functions, arriving at a combined set of equations and a mathematical model to be processed on the computer.

(b)-Formulation - The formulation of an actual mining operation is herewith presented in a very much abbreviated form:

- (i) - A Flow Diagram must be established representing the entire operations for the several mines and establishes a basis of the necessary framework for the analyst.
- (ii) - Factors affecting the Operations must identify and define all constants, variables and coefficients, constraints and limitations. These are:
 - a - Location of the mines with reference to transport routes and loading terminal.
 - b - Geological Description of the mines with cross sections of the ore bodies and types of in situ ore.
 - c - Mining Operations are based on open pit mining benches of 6 to 12 m high and annual production of 800 000 T and 4 500 000 T; two 8-hr shifts for excavation, hauling, crushing and loading and one 8-hr shift for drilling with blasting occurring once a day between shifts.
 - i. - Drilling and blasting and necessary equipment depend on density of ore, types to be encountered, abrasiveness, bit and drill steel life and other factors, such as properties of terrain and amount of waste material. The type and operational cost of equipment is investigated and tabulated.
 - ii - Loading units depend on cost per cubic meter handled, job conditions and economic conditions.
These items are influenced by total volume handled, cost of the equipment, operating and labor costs, operating range, dipper size, digging force at tooth point, time allowable and hauling unit size. In addition, economic conditions may become a deciding factor because of available capital and its cost, investment caution due to uncertainty of production rate, availability of used machines, etc.
 - iii - Hauling units are a somewhat lesser problem because deficiencies can be remedied by additional units, which is not the case with loading machine. However, it is important to determine size, number of units, down time, standby, synchronization through traffic control, body size, tire types, etc.

- iv - Crushing and Screening and selection of equipment is made and all data graphically assembled; the following factors have an important bearing upon the choice of equipment : characteristics of the material, hourly production, product size or discharge setting, type and size of quarrying equipment and method of feed to the crusher.
- v - Conveyor analysis is then made to determine the incline, length, feed rate, capacity, belt width, speed, HP requirements and costs.
- vi - Transportation over the railroad and loading at the port is then analysed, tabulated and graphically shown. The transportation problem requires complete description of types and number of cars, locomotives, cycles, road conditions and grades, loading and unloading cycles, and costs. The present port has successfully handled over 5 000 000 T in 1961, but limitations of draft and channel width permit only carriers of up to 45 000 T, and those not too economically. The new port, now under construction, will handle ore carriers to 100 000 DWT, provide a stockpile of 1 600 000 T of iron ore, 400 000 T of coal and shipload ore at a rate of 6 000 TPH initially and 12 000 TPH in the final installation.

(c)-Result - The detailed information concerning all operations then enables the computer to tie together all constraints, specification and limitations of the total mining operation, and combining it with the economic side of the picture, an optimum operation plan then can be devised.

The final result in tabulated form will then show a cost analysis of the operations of the various mines. This of course can be made for one mine or expanded to include several mines. From this table the profit for each grade of ore can be determined, which in turn would lead to one of the objectives that, of maximizing the total profit for all mines. Thus given the profit per ton of each grade of ore as P_1, P_2, P_3 , etc., and G_1, G_2, G_3 , etc. as tons of ore of grades 1, 2, 3, etc., the matrix is then expressed as follows:

$$\begin{aligned}
 &P_1 G_1 + P_2 G_2 + P_3 G_3 + \dots + P_n G_n = \text{maximum} \\
 \text{subject to} \quad &G_1 + G_2 + G_3 + \dots + G_n \leq \text{Total mining capacity} \\
 &G_2 + G_3 + \dots + G_n \leq C_2 \\
 &G_3 + \dots + G_n \leq C_3 \\
 &G_n \leq C_n
 \end{aligned}$$

where C_1, C_2, C_3 , etc. are screen capacities.

Feeding this linear programming model into the computer the number of tons of each grade to be produced can be determined to obtain the maximum profit. Having determined the amounts of various grades to be produced, the computer then calculates the crusher settings of all crushers to give a desired screen analysis at the specified production rate, feed back rate, screen sizes, etc. Similarly, train compositions and optimum speed can be determined for lowest operating costs.

5 - CONCLUSION

It can be said that, if computer techniques have given management in the U. S. and Europe a valuable tool for executive and technical decisions, these computer techniques are even more valuable to the Brazilian economy and Brazilian executives for the following reasons:

- (a) - Due to the inflationary economy, sudden political changes and surprising unexpected government decisions, the evaluation of changing factors and of increased number of variable factors becomes an impossible burden for anything except high speed computer assistance, to supply the necessary information in time for sound management decisions.
- (b) - The scarcity of experienced middle-rank managers and technicians point strongly to the value of greater utilization of computer techniques.

This company, as a result of planning for long-range objectives, has created a Division of Development, which also undertakes research into advanced technological methods for possible and profitable inclusion in the company's operation. These problems and their solutions, being of very specialized and complex nature, require the assistance of experts in the field. The company has in the past and will continue to call on the cooperation of consultants of international renown.

